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EVALUATION, ANALYSIS, AND DOCUMENTATION SUPPORT FOR THE 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT (SLEEP)

TECHNICAL REPORT

Science Applications International Corporation

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EVALUATION, ANALYSIS, AND DOCUMENTATION SUPPORT FOR THE 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT (SLEEP)

TECHNICAL REPORT

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The US Army identified the need for a Signature Suppressed, Lightweight Electric Energy Plant (SLEEP) to improve the survivability of forward deployed units. The US Army Belvoir Research, Development and Engineering Center has the responsibility for procuring generators to meet this requirement. This study was to investigate power generation technology and determine the most effective technology to meet the SLEEP requirement.

The Stirling was identified as the most promising technology for SLEEP. Commercial systems and improvements to existing systems cannot meet this requirement. Procurement of SLEEP was determined to be well suited for the Army Streamlined Acquisition Program.

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Rotary Diesel Engine, Phosphoric Acid Fuel Cell.

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PRINCIPAL FINDINGS

1. SLEEP requirements cannot be met by a Product Improvement Program (PIP) for generator sets currently in the Army inventory nor a Non-Development Item (NDI) acquisition of commercial products. The inability to meet these requirements is due primarily to the high weight and signature profiles of the existing generator sets.

2. The assessment of power generation technologies revealed three feasible alternatives for SLEEP: Phosphoric Acid Fuel Cells, Rotary Diesel engines, and Stirling engines. Analyses indicated that Rotary technology cannot meet the SLEEP requirement due to problems meeting signature goals within the specified weight limits. Fuel cells are unable to meet SLEEP requirements in the near term due to their immature state of development.

3. The absence of PIP and NDI solutions necessitates initiation of a research and development program to be initiated to meet these requirements. The technologies that provide near term solutions require commencment of an engine development program. The SLEEP development effort is well suited for the Army Streamlined Acquisition Program (ASAP).

4. The Stirling engine was determined to be the optimal alternative for SLEEP. Free Piston and Kinematic Stirling technologies are projected to be excellent candidates for development. Stirling is a mid-term technology that is projected to meet all SLEEP requirements. In addition, the projected advantages of this technology outweigh the disadvantages inherent in a new engine development program.

MAIN ASSUMPTIONS

The SLEEP program will have a similar cost and schedule as other ASAP generator programs recently initiated by the Army.

PRINCIPAL LIMITATIONS

Actual performance data was not available for all technologies. Relative comparisons of technology performance were required in most cases.

SCOPE OF EFFORT

This analysis applies to all technologies able to meet two constraints. The first limiting parameter required a technology to provide 10 kW power for military appliactions. The second constraint limited the study scope to those technologies which could meet the SLEEP system requirements.

OBJECTIVES

This study has three objectives: evaluation of technology applicable to military power generation systems, examination of technology to meet materiel requirements, preparation of procurement documentation which will allow SLEEP to be incorporated into the materiel acquisition process and facilitate prototype hardware procurement.

BASIC APPROACH

This study contains a Requirements Analysis examining system requirements and determining the technical impact; a Technical Assessment examining commercial generators, literature review of current research, and to identify feasible alternatives; a Feasibility Analysis examining each feasible alternative and identifying the optimal alternative; a Sensitivity Analysis evaluating options if requirements are relaxed; and preparing of materiel acquisition documentation.

REASON FOR PERFORMING STUDY

This study determines the optimal developmental approach and the most promising technology to meet the SLEEP requirements.

IMPACT OF THE STUDY

This study provides information concerning technical and development options for use in future materiel acquisition decisions.

SPONSOR

US Army Belvoir Research, Development, and Engineering Center

PRINCIPAL INVESTIGATOR

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1. INTRODUCTION

1.1 Background.

The mission capability and survivability of critical US Army units operating in forward areas is threatened by the development and use of threat aural and thermal detection and analysis equipment. These increasingly common detection and analysis tools allow threat forces to identify and target specific types of units through analysis of the high aural and thermal signatures produced by current electric power generation equipment. Each type of unit often has unique power requirements causing unique generator signatures. The high aural signatures produced by standard generators can also mask the sound of enemy movement and intruders.

In addition to systems with high signatures, gasoline internal combustion engine driven systems characterize the current fleet of standard electric power generators. Nearly one-half of the current systems have exceeded their design life. These characteristics create supply problems due to non-standard Petroleum, Oil, and Lubricant (POL) requirements, low reliability, and high support asset demands.

Improving unit survivability and mission performance led to the requirement for the Signature Suppressed, Lightweight Electric Energy Plant (SLEEP). The SLEEP requirement identifies a family of lightweight, compact, mobile, reliable, and multifuel electric power plants that are difficult to detect by aural and thermal methods. The SLEEP units must be interchangeable with existing standard generator sets of the same power rating. The SLEEP generator sets will replace the standard sets in form, fit, and function in nuclear capable delivery units and associated combat service support elements; signal units; air defense units; combat arms command, control, and communications units; and logistics functions in the brigade area. Priority replacement will be provided to nuclear capable delivery units and their associated elements.

The need for a SLEEP generator system has existed for over ten years. The SLEEP Required Operational Capability (ROC), approved in 1975, specified the development of an entire family of SLEEP sets with power ratings of 0.5 kW, 1.5 kW, 3 kW, 5 kW, and 10 kW. The SLEEP ROC also cites several technology alternatives for research and development. These alternatives were drawn from a previous study as the most attractive development options for silent tactical power requirements.[1] The designated technologies are specified for particular ranges of power ratings. The study identified the organic Rankine cycle engine generator and the phosphoric acid fuel cell technologies for power ratings up to 5 kW and an enclosure silenced open Brayton cycle for ratings over 5 kW. Research and development programs initiated for each of these technologies concluded without producing a system meeting the SLEEP requirement. An unapproved revision to the 1975 ROC does not specify alternative systems. The revision does indicate that meeting the requirement will necessitate using state-of-the-art technology.

1.2 Purpose.

This analysis identifies the technology alternatives able to meet the 10 kW SLEEP requirement as stated in the ROC. This study also identifies the most optimal procedures for the procurement and fielding of hardware.

1.3 Objective.

This study has three objectives. The first is an in-depth evaluation of technology alternatives applicable to the development of military power generation systems. The second examines these alternatives with respect to fulfilling the materiel requirements. The third objective is to prepare the procurement documentation which will allow the incorporation of SLEEP into the materiel acquisition process and facilitate prototype hardware procurement.

1.4 Technical Approach.

The approach used in this study consists of six parts: requirements analysis, technical assessment, feasibility analysis, sensitivity analysis, acquisition approach, and preparation of acquisition documentation. The requirements analysis examined the system requirements documents and consolidated the requirements into an aggregate. The technology assessment included examination of data on commercial generator sets, review of technical literature to determine research areas, on-site visits to research and development firms involved in technologies applicable to SLEEP, and identification of the alternatives with the greatest potential for application to the SLEEP. The feasibility analysis examined the viable alternatives to determine the alternative which shows the most promise for development. This analysis also included a risk assessment and trade-off study of each viable alternative. The sensitivity analysis examined the impact of SLEEP requirements relaxation on development options and alternatives. The acquisition approach evaluated the various possible procurement approaches available to SLEEP. The preparation of procurement documentation will allow the SLEEP program to move into engineering development and the authority to procure prototype hardware.

1.5 Scope.

This analysis is based on two fundamental assumptions. The first assumes that the technology alternatives are suitable for a 10 kW military electric power generation system. The second assumption is that the system selected must meet the requirements as stated in the SLEEP ROC.

2. ARMY REQUIREMENTS FOR THE SIGNATURE SUPPRESSED, LIGHTWEIGHT ELECTRIC ENERGY PLANT (SLEEP)

Requirements documents form the foundation for the SLEEP procurement program. These include the ROC, approved in 1975, the Operational and Organizational Plan (O&O Plan), approved in 1985, and an unapproved revision to the 1975 ROC. The requirements analysis which follows evaluates and consolidates these documents and examines and compares SLEEP requirements to the requirements for several other mobile electric power programs. Following the SLEEP requirements presentation is a comparison of selected SLEEP requirements to certain specifications and performance measurements for these Army programs: the 15 kW Signature Suppressed Diesel Engine Driven (SSDED) Generator, the DOD Standard 10kW Diesel Engine Driven (DOD-STD DED) Generator, and the DOD Standard Gas Turbine Engine Driven (DOD-STD GTED) Generator. These comparisons indicates the stringent and unique constraints imposed by the SLEEP requirements.

2.1 <u>SLEEP Requirements</u>.

The SLEEP requirements contain general, specific, and system development information. The general requirements include broad statements concerning the overall features and the configuration of SLEEP generator sets. These requirements address system characteristics that are not quantified. The specific requirements contain detailed design criteria and performance specifications. These requirements may be quantified. SLEEP requirements are divided into categories which include Reliability, Availability, and Maintainability (RAM); Electrical Performance; Signature Suppression; Transportability; Physical Characteristics; POL; Survivability and Threats; Operational Requirements; Operations and Maintenance; Operational Environment; Starting; and Miscellaneous.

2.1.1 Reliability, Availability, and Maintainability (RAM).

The RAM requirements for the SLEEP set follow:

- o Reliability

oo Continuous mission capability	360 hours
oo Mean Time Between Operational Mission Failure (MTBOMF)	
ooo Best Operational Capability	600 hours
ooo Minimum Acceptable Value	400 hours

- o Operational Availability (A_0)

oo Wartime	0.95
oo Peacetime	0.95

- o Maintainability

oo Maintenance Ratio	
ooo Organizational	0.065
ooo Direct Support	0.035
ooo General Support	0.022
oo Maximum service and check out time	30 minutes
oo One person oil change capability	

2.1.2 Electrical Performance.

The SLEEP electrical performance for alternating current (AC) and direct current (DC) power must conform to MIL-STD 1332 and the following requirements:

- o Modes of operation include 60 and 400 Hz and DC.
- o Transient and steady-state performance must conform to utility power requirements of MIL-STD 1332.
- o The electrical performance and output may not deteriorate more than 10% between altitudes of 5000 and 8000 feet.
- o The electromagnetic compatibility and interference characteristics must be below the UM04 limits of MIL-STD 461 for class 2 equipment.

2.1.3 Signature Suppression.

SLEEP signature suppression requirements are stated below:

- o Aural signature suppression
  - oo The set may emit no detectable aural signature above ambient conditions at 100 meters as specified by Octave Bands levels of MIL-STD 1474.
- o Thermal signature suppression
  - oo The set temperature image may not vary more than +/- 4°C from ambient background with 90% surface area exposed.

2.1.4 Transportability.

The requirements for transportation of SLEEP include:

- o Lightweight and compact design
- o Transportable by tactical vehicle
- o Skid mounting
- o Lifting attachments and tiedowns
- o Transportable by USAF C-130, C-141 and all US Army aircraft
- o Capability for low velocity air drop (with packaging) and low altitude parachute extraction capability
- o The following terrain conditions and usage are prescribed:

Terrain Type	Usage
primary roads	20 %
secondary roads	30 %
off road	50 %

2.1.5 Physical Characteristics.

The physical characteristics of the SLEEP follow:

o Power	10 kilowatt
o Maximum Volume	30 cubic feet
o Maximum Height	96 inches
o Maximum Weight	650 pounds
oo Maximum Tow Tongue Weight	200 pounds

2.1.6 Petroleum, Oil, and Lubricants (POL).

POL requirements for SLEEP include the following:

- o Multifuel capability with diesel as the primary fuel
- o Required use of military standard fuels, lubricants, and coolants
- o Specified fuels (MIL-SPEC grades)
  - oo Diesel
  - oo JP 4,5, & 8
  - oo Kerosene
  - oo Synthetic fuels
  - oo All DOD logistical fuels
- o Only oils and lubricants currently available through the DOD supply system
- o Required onboard fuel tank with 8 hour operation capability

2.1.7 Survivability and Threats.

Requirements for SLEEP survivability include:

- o Nuclear, Biological, and Chemical (NBC) survivability required at least to the level of the systems typically supported
- o Nuclear hardening for high altitude Electromagnetic Pulse (EMP) survivability is required
- o Minimize effects of Chemical, Biological, and Radiological (CBR), fire, blast, etc.
- o Chemical Agent Resistance Coating (CARC) paint where applicable

Threats to SLEEP include:

- o Small arms
- o Artillery
- o Missiles
- o Armed helicopter
- o Fighter bomber
- o Directed energy
- o Electromagnetic pulse
- o Special purpose forces

- Unconventional Warfare (UW) teams
- Saboteurs

2.1.8 Operational Requirement.

The operational requirements for the SLEEP set are summarized in the following tables.

- 15 Day Intense Wartime Mission Requirements

Task	Time Each Day	Total Time
Operating time	21.5 hours	322.5 hours
Standby time	1.0 hours	15.0 hours
Movement time	1.5 hours	22.5 hours
	Total	360 hours

- Typical 24 Hour Mission Requirement

Service checks	1.0 hour		4 %	
Operate at demand levels	21.5 hours		90 %	
Full load		1 hour		4 %
75 % load		7 hours		29 %
50 % load		7 hours		29 %
Less than 50 %		5 hours		22 %
Less than 10 %		1.5 hours		6 %
Movement time	1.5 hours		6 %	
Total time	24 hours		100%	

2.1.9 Operations and Maintenance.

The requirements for operation and maintenance of the SLEEP include the following:

- Operable and repairable by 5th to 95th percent soldiers in arctic or Mission Oriented Protective Posture (MOPP) IV protective clothing
- Unattended operation
- One person start-up and shutdown capability
- No special tools or equipment for operation or maintenance
- Cranking and battery charging system and DC slave receptacle compatible with designated prime mover
- Fully interoperable with existing generator sets and transport systems
- Health, safety, and human factors engineering (HFE) requirements are applicable

2.1.10 Operational Environment.

The operational environment for SLEEP is identified below:

- Operable at altitudes from sea level to 8000 feet at 95°F
- Operable in climate conditions of hot, basic, cold, and severe cold
- Operable in basic climate to 107°F below 5000 feet
- Operable on sloping terrain to 15 degrees on any axis
- Usable in reduced visibility conditions
- The following environmental conditions and usage are prescribed:

Environmental Conditions	Usage
Hot	15%
Basic	80%
Cold	< 5%
Severe Cold	< 1%

2.1.11 Starting.

Requirements for starting the SLEEP generator set include:

- o Electric/stored energy starting system with self contained power source/automatic regeneration of starter power source
- o 15-25 minute start-up (full power) time at temperatures above 25°F
- o 25-30 minute start-up (full power) time at temperatures below 25°F

2.1.12 Miscellaneous.

Other requirements for SLEEP include:

- o All climate capability
- o All shelter capability
- o Vehicle and stationary battery charging capabilities
- o Cooling means to allow operation at rated load without overheating
- o Direct interface means with DISE (Distribution Illumination Systems, Electrical)

2.2 Comparison of Requirements.

A comparison of existing and anticipated requirements for major Army generators illustrates how the SLEEP requirements diverge from the requirements for other mobile electric power systems. The systems compared include: SLEEP, SSDED, DOD-STD DED, and DOD-STD GTED generators. As Table 2-1 demonstrates, SLEEP is a unique program due to the stringent requirements. The SLEEP requirements significantly constrain the design and development alternatives available to SLEEP.

TABLE 2-1. COMPARISON OF ARMY GENERATOR SETS REQUIREMENTS.

CATEGORY	DATA TYPE			
	SYSTEM REQUIREMENTS		SYSTEM PERFORMANCE	
	10kW SLEEP	15kW SSDED	10kW DOD-STD DED	10kW DOD-STD GTED
WEIGHT (lbs.)	650	2450-2500	1240-1325	300-465
VOLUME (cu. ft.)	30	90	40	10-20
AURAL DETECTION (meters)	100	300	--	--
THERMAL SIGNATURE (^{o}C amb)	4	10	--	--
RELIABILITY (MTBF-hrs)	600	800	500	500-750

It is useful to compare some of the SLEEP requirements to the requirements of mobile electric power systems in research and development, as well as the actual performance of power systems currently in use by the Army. The SLEEP requirements were compared to the SSDED specification and Purchase Description and to the actual performance of the DOD-STD DED and GTED generators.

The largest difference between the SLEEP and the SSDED are in the weight and signature areas. Although the SSDED specifies power ranges from 15 to 60 kW, the SSDED can be nearly four times heavier than the 10 kW SLEEP generator with much less strict signature requirements. The aural signature for SSDED is less stringent than the SLEEP requirement by a factor of three. The thermal signature requirements for SSDED are two and one-half times less demanding as those for SLEEP.

These comparisons become more meaningful when SLEEP requirements are compared to the actual performance of DOD-STD generator sets. The minimum weight of the DOD-STD DED is nearly twice that specified for SLEEP, with no restriction on aural or thermal detectability. The DOD-STD GTED is less than half the prescribed weight of SLEEP but, again, there are no signature restrictions.

Reliability also points out the divergence of SLEEP requirements with other program requirements. The SLEEP reliability requirement is 200 hours, (33%) lower than the SSDED yet is 100 hours (16%) higher that the DOD-STD DED. These comparisons indicate the stringent and unique constraints imposed by the SLEEP requirements.

3. TECHNICAL ASSESSMENT

This study evaluates all technology options with the potential capability to meet SLEEP requirements and applications. The study focuses on identifying systems leading to procurement of a SLEEP generator system. The system must meet all requirements and demonstrate high performance while minimizing costs, procurement schedules, and developmental risk to the Government. The following technologies and systems were examined:

Acoustic Enclosures
Adiabatic Diesel Engines
Brayton Cycle Engines
Free Piston Stirling Engines
Fuel Cells
Hybrid Generator Systems
Kinematic Stirling Engines
Rankine Cycle Engines
Rotary Diesel Engines
Standard Diesel Engines
Thermally Regenerative Batteries
Thermionic Generators
Thermoelectric Generators
Photovoltaic Generators

3.1 Commercial Products Status Assessment.

Materiel procured from the commercial marketplace for introduction, either directly or with modifications, into the Army system allows the Government to accelerate the procurement process and reduce costs. To determine if existing technology can meet the SLEEP requirements with commercial hardware required a thorough survey of commercially available generator sets and engines. Such a survey has been completed. This

Commercial Products Status Assessment describes the procedures and results of the survey.

This survey attempted to identify commercially available generator sets meeting the SLEEP requirements. Using the requirements taken from the requirements documents (the ROC and the O&O Plan), the Engine-Generator Set Database, Version II (GENII), developed in February 1987, was queried for all commercially available generators meeting the SLEEP requirements.[2] This database is a Government owned database which contains specifications and performance criteria on numerous commercially available power generation sets and systems. A resident expert for this database assisted throughout the query to ensure a thorough database search.

3.1.1 Procedure.

The query involved the input of pertinent SLEEP requirements into the database. The selection criteria, shown in Figure 3-1, included generators of any set name, manufacturer, and country. The rated power level was limited to the specified 10 kW using a range of 9 to 11 kW. The weight specification for the generator was not to exceed 650 pounds. The ROC specifies that the SLEEP generator set emit no detectable aural signature at 100 meters. This query used an equivalent requirement, contained in Military Standard 1474B, of no greater than 45 decibels (dB) average at 7 meters. Output voltage, output frequencies, and technology alternatives were not limited in this survey to ensure a thorough query. The requirements specify multifuel capability; however, all systems must accommodate diesel fuel. Accordingly, this query indicated diesel fuel as the primary fuel. System size, while not directly queried, was subsequently evaluated with respect to the SLEEP requirements using the survey output.

3.1.2 Results.

The output of the database query yielded no commercially available systems which meet all of the SLEEP requirements. Successive queries varying parameters did produce potential systems and manufacturers. The

THE SETS SHOWN BELOW WERE IDENTIFIED IN RESPONSE TO THE FOLLOWING INQUIRY:

Find all generator sets meeting all selection criteria outlined below:

Set name: ANY
Manufacturer name: ANY
Country of origin: ANY

Rated power from 9. kW to 11. kW
Weight not exceeding 650 Lbs
Acoustic noise level not exceeding 45 dB

Any output voltages indicated below:

X 120 V	X 120/208 V	X 240/416 V	X 28 DC
X 115/200 V	X 120/240 V	X 277/480 V	X Other

Any output frequencies indicated below:

X 50 Hz AC X 50/60 Hz AC X 60 Hz AC X 400 Hz AC X DC

Any technologies indicated below:

X Diesel Engine	Gas Turbine Engine	Thermoelectric
Fuel Cell	Gasoline Engine	Other

Any primary fuel types indicated below:

X Diesel Fuel	Methanol	Gasoline
Aviation Turbine Fuel	Kerosene	Other

FIGURE 3-1 DATABASE SELECTION CRITERIA

parameters varied were weight, fuel, and acoustic level. In this application, the variation allows the parameter to assume any value. The query results are tabulated and listed by manufacturer in Table 3-1. An examination of the table shows certain generator sets which may meet the requirements; however, further study revealed that all systems fail to meet the SLEEP requirements in at least one category. The table contains several generator sets which meet weight, volume and fuel requirements and do not have a noise measurement in the database. Further investigation revealed that the manufacturers of these systems do not have noise measurement data which indicates that these systems have aural signatures in excess of the SLEEP requirement. These sets are assumed to have aural signatures equal to or greater than signatures of those sets in the database which do have noise measurements. Reduction of aural signatures of these magnitudes (70 - 90 dB at 7 meters) to the level necessary to meet the SLEEP requirement would require an extensive development effort.

The results of this database query indicate that no commercially available generator systems meet all the SLEEP requirements. Therefore, a commercially available generator set is not an option for SLEEP.

TABLE 3-1
10KW GENERATOR DATA SAMPLE

MANUFACTURER	TECHNOLOGY	WEIGHT (LBS)	LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)	NOISE (dB @ 7M)	TEMPERATURE (^{O}F @ FT)		COST ($)	FUELS
1	DIESEL	3968	169	69	**67**					D
2	DIESEL	1065	63	30	**63**		85	500		D
3	DIESEL	975	**48**	**24**	**35**	77	85	500		D,JP4
4	DIESEL	750	60	29	**34**	90	70	1500	5031	D,K
5	DIESEL	785	**54**	**21**	**33**	85				D
6	DIESEL	920	40	36	**38**	81	85	1000	7300	D,JP5
7	DIESEL	2586	101	31	**48**					D
8	DIESEL	831	**46**	**26**	**41**					D
9	DIESEL	975	**48**	**24**	**35**					D

* MORE THAN ONE ENGINE OFFERED WITH THIS SET
D = DIESEL K = KEROSENE GAS = GASOLINE
BOLD INDICATES CHARACTERISTIC MEETS SLEEP SPECIFICATIONS

TABLE 3-1
10KW GENERATOR DATA SAMPLE

MANUFACTURER	TECHNOLOGY	WEIGHT (LBS)	LENGTH (IN)	WIDTH (IN)	HEIGHT (IN)	NOISE (dB @ 7M)	TEMPERATURE (^{0}F @ FT)		COST ($)	FUELS
10	DIESEL	1240	62	32	**37**	77	50	0		D,JP4
	GAS	850	**57**	**30**	**29**	82	50	0		GAS
	TURBINE	**456**	**45**	**29**	**36**	79	50	0		JP4,GAS
11	GAS	890	52	36	**35**					GAS
	DIESEL	925	54	28	**36**					D
12	GAS	**647**	**42**	**31**	**33**		86	0		GAS
	GAS	**628**	**39**	**27**	**31**		86	0		GAS
	GAS*	688	**57**	**26**	**32**		86	0		GAS
13	DIESEL	1105	68	34	**43**					D
14	DIESEL	750	**43**	**23**	**29**	77	60	0	5455	D
		627	**36**	**28**	**32**		60	0	4975	D

* MORE THAN ONE ENGINE OFFERED WITH THIS SET
D = DIESEL K = KEROSENE GAS = GASOLINE
BOLD INDICATES CHARACTERISTIC MEETS SLEEP SPECIFICATIONS

TABLE 3-1
10KW GENERATOR DATA SAMPLE

	MANUFACTURER	LOCATION
1	ACEC SA, GP DEF AND TELECOM	BRUSSELS, BELGIUM
2	ALLIS-CHALMERS CORP, ENGINE DIV	HARVEY, IL
3	AMIDA INDUSTRIES, INC.	ROCK HILL, SC
4	BLANCHARD MACHINERY CO	COLUMBIA, SC
5	DALE ELECTRIC OF GREAT BRITAIN, LTD	UK
6	ENGINE TECHNOLOGY, INC	MORGANVILLE, NJ
7	HOUVENAGHEL, SA	L'EPINAY, FRANCE
8	KOHLER CO	KOHLER, WI
9	LISTER DIESELS, INC	OLATHE, KS
10	DOD STANDARD SETS	SPRINGFIELD, VA*
11	REAGAN EQUIPMENT CO	HARVEY, LA
12	T&J MANUFACTURING, INC	OSHKOSH, WI
13	VM GROUP OF AMERICA	HOUSTON, TX
14	WINPOWER CORPORATION	NEWTON, IA

SOURCE: BELVOIR ENGINE GENERATOR SET DATABASE FEBRUARY 1987

* Not a manufacturer. Listed for comparison purposes only.

3.2 Preliminary Evaluation.

This evaluation seeks insight into the ability of state-of-the-art technology to meet the SLEEP requirements. Investigating currently available or developmental power generation technology applicable to SLEEP required an extensive research effort. Applicable documents were identified and obtained with the assistance of the Defense Technical Information Center (DTIC) and the National Technical Information Service (NTIS), and the resources of the George Washington University and the University of Maryland libraries. The three volume set of the 1986 Intersociety Energy Conversion Engineering Conference (IECEC) proceedings containing in excess of 2100 pages of papers, plus over seventy additional technical papers, were examined to fully investigate the technological possibilities.

The initial stages of this research effort provided information which enabled the elimination of four technology options for SLEEP. These technologies include: Photovoltaic Generators, Thermally Regenerative Batteries, Thermionic Generators, and Thermoelectric Generators.

Photovoltaic Generators were eliminated due to their inability to function in all possible combat situations. The battlefield environment could effectively obliterate the fuel source (obscure the sun), making this technology an unreliable alternative.

Thermally Regenerative Batteries, Thermionic Generators, and Thermoelectric Generators were eliminated because of performance uncertainty and their inability to meet the requirements. Very litt applicable research and development work has been published on these technologies recently because they lack commercial uses and interest. Since these options have no applicable research base, developing a SLEEP generator set using these technology options would require an unreasonable developmental effort. Pursuing these technology alternatives for SLEEP would also incur unnecessarily high cost, schedule, and technical risks.

Based upon additional information found during the research effort four of the remaining technology alternatives may be eliminated: closed and open Brayton cycle engine, adiabatic Diesel engine, standard Diesel engine, and Rankine cycle engine. Although these alternatives do not lack pertinent research support or commercial application, these options fail to offer systems capable of meeting the SLEEP requirements.

The open Brayton cycle engine (gas turbine engine) failed to present a viable alternative for the SLEEP program based upon the inherent operational characteristics of the engine. The Brayton cycle engine requires large volumes of air for operation. Suppressing the noise produced by the intake and exhaust airflow may be possible, at the expense of additional weight and volume. Prototype work has been done in this area with limited success. A production representative turboalternator was silenced using an enclosure to meet SLEEP requirements. The resulting generator came very close to meeting the aural signature requirement; however, the weight was one and one half times greater than the requirement. In addition to the noise produced by the Brayton engine, the large volume of high temperature exhaust causes thermal suppression difficulties. Once again, the signature requirements coupled with the weight requirements eliminate the Brayton as an alternative for SLEEP.

Elimination of the standard and adiabatic Diesel engines is based upon system weight and noise emissions. The standard Diesel engine can weigh one and one half times greater than the requirement. Although lighter than the standard engine, the adiabatic Diesel engine also suffers from high engine weight far in excess of the requirement. Both engines possess high aural and thermal signatures which necessitate auxiliary suppression systems, further increasing system weight. Coupling the signature and weight SLEEP requirements forces the elimination of the standard and adiabatic Diesel engines as viable SLEEP alternatives.

The Rankine cycle engine currently enjoys broad acceptance in applications such as the electric utilities, where system bulk and weight hold little significance. Research in this field has not indicated an

interest in scaling Rankine engines to the greatly reduced SLEEP magnitude. Based on current research and applications, the Rankine cycle engine was eliminated from consideration for SLEEP.

Three technology areas emerged from the literature search and research effort as having high potential for the SLEEP program. These technology options include: Rotary Diesel Engines, Stirling Engines, and Fuel Cells. Detailed discussion of these three technology alternatives follows.

To better evaluate current developmental programs and the state-of-the-art, representative companies in these technology areas were contacted. On site visits enabled a complete, fair, and objective analysis of those technologies with the best potential to meet the SLEEP program objectives.

3.3 Primary Evaluation.

This evaluation discusses each of the three technology options with potential for the SLEEP program: Rotary, Stirling, and Fuel Cells. Each technology alternative is discussed in detail concerning the advantages, disadvantages, and the current state-of-the-art in the each particular technology. As a means to compare the technology alternatives, Table 3-2 presents the current data for each technology option. Although eliminated as an alternative, the table lists the data on standard diesel engine for comparison purposes.

3.4 Rotary Diesel Engine Technology.

The Rotary Diesel engine technology benefits from many of the advantages of standard diesel engines. The Rotary Diesel engine technology is adapted from a familiar, mature, and proven technology option. A gasoline Rotary engine has been successfully produced and operated for several years. As a result, the Rotary Diesel engine technology benefits from an existing manufacturing base and logistics support network. However, significant

TABLE 3-2

COMPARISON OF TECHNOLOGIES - CURRENT CAPABILITIES

PARAMETER	REQUIREMENT	TECHNOLOGY				
		Diesel	Rotary	Kinematic Stirling	Free Piston Stirling	Fuel Cell
Power	10 kW	10	60	60	.175	20
Weight	650 lbs	1240	450	700	7	780
Volume	30 ft^3	42.5	5.4	10.2	.01	26.0
Fuel(s)	Diesel	Diesel	Multifuel	Multifuel	Multifuel	Multifuel
Aural Signature	0 dB @ 100 m	80-85	80-85	65-70	not available	nil
Exhaust Temperature	+/- $4^{o}C$	315	315	83	not available	nil
Maturity		Production	Prototype	Prototype	Production	Laboratory
MTBF	600 hrs	675		500 est.		1800

doubt remains as to whether the Rotary Diesel technology can meet all the SLEEP requirements. The Rotary engine, an internal combustion engine, is inherently loud, albeit quieter than a standard diesel engine. Meeting the acoustic and thermal signature requirements concurrently with the low weight specified will prove a difficult challenge for a developmental Rotary Diesel SLEEP program.

3.4.1 Advantages of Rotary Diesels.

The primary advantages the Rotary Diesel technology offers include very low engine weight and size, fewer moving parts, multifuel operation, and existing logistic support and manufacturing bases able to adapt to this technology.

The low weight and small size of the Rotary Diesel allow use of the engine in many more applications than reciprocating diesel engines. For SLEEP this provides weight and space for a noise attenuation system. This compact power plant is very attractive for other uses.

The simplicity and reduction in parts from the standard diesel will allow reduced maintenance support for the Rotary. This will in turn reduce sustainment costs over current systems. Improved reliability due to design simplicity will increase operational readiness and decrease corrective maintenance actions.

A gasoline fueled Rotary engine is currently in production for the commercial automotive market. This engine provides operational experience applicable to the Rotary Diesel. This experience will accelerate the transition to production and reduce problems associated with the transition.

3.4.2 Current Status of Rotary Diesel Engines.

The automotive industry currently employs a gasoline version of a Rotary engine. The potential for this technology encourages significant research work to improve the state-of-the-art. As a result, the Rotary Diesel engine

has received much research attention. The applications for Rotary technology includes a large spectrum, heavy trucks to lightweight aircraft.

Significant research efforts continue to develop Rotary Diesel engines. These engines, by employing fewer moving parts and eliminating the reciprocating motion of a conventional internal combustion engine, offer notable advantages for a SLEEP application. Currently, a family of large (60 kW - 1680 kW) Rotary engines is in transition from prototype to production stages.[3] Due to the geometric similarity throughout the family of engines, down-sizing to a 10 kW SLEEP engine should be possible. It should be noted that a gasoline powered rotary engine is currently available which weighs 23 pounds yet produces up to 38 brake horsepower (approximately 28 kW).[4]

In spite of these advances, meeting the SLEEP aural and thermal requirements using the Rotary Diesel engine technology will require a noise enclosure for adequate signature suppression. Given the understanding of the Rotary Diesel technology, much of the developmental effort will necessarily focus upon the enclosure. However, meeting the stringent acoustic and thermal SLEEP requirements necessitates a system approach to signature suppression. Modifications to the Rotary Diesel system will likely be required. Changes to the system could include vibration isolation mountings, increasing the mass of engine cases, and altering auxiliary equipment configurations. The contributions auxiliary equipment make to noise generation must also receive consideration in the SLEEP effort. A major step forward in acoustic suppression, such as SLEEP, will require system level developmental efforts.

Noise generation sources, suppression methods, and the subsequent production of acoustic enclosures are well documented. However, each acoustic suppression problem has unique constraints, characteristics, and requirements, and requires a unique approach to solve. In addition, current industrial applications rarely concentrate upon thermal signature suppression. Therefore, any approach to signature suppression in meeting

the SLEEP requirements must consider the impacts of aural and thermal signature suppression concurrently in a Rotary Diesel development program.

In addition to the Rotary Diesel engine, other areas of research work focus upon improving the overall engine efficiency. These areas include turbocharging (used in the smaller Rotary engines), after cooling, turbocompounding, and adiabatics. Turbocharging and turbocompounding improve engine efficiency by increasing fuel-air mixture temperature. Adiabatics reduces the heat rejected by the engine through the elimination of the cooling systems, insulating the engine to reduce heat transfer, and reclaiming exhaust heat energy. Engine efficiency projections predict an increase in excess of 30% using an adiabatic engine.[5] Adiabatic diesel Rotary engines are currently in development; however, these engines rely on ceramic technology which still requires development.

3.4.3 Rotary Diesel Technology Data.

The typical diesel engine generates 80 - 85 dB of noise during unsuppressed operation. Although the Rotary Diesel engine has fewer moving parts than a standard diesel engine, as an internal combustion engine it still generates 75 - 80 dB of noise. This noise level contains many different frequencies. Since attenuation depends upon frequency, proper acoustic suppression must consider the frequency of the noise generated. Generally, the high frequency sound waves present few suppression difficulties. However, high frequency noise does create potential sealing difficulties. Low frequency noise presents a much more difficult problem in suppression due to the permeability of materials to low frequency sound.

Rough estimates of acoustic suppression levels and methods yield a level which might meet the SLEEP requirements. An overall projected noise attenuation of 35 - 40 dBA is considered possible. This would include a 40-50 dBA attenuation in the high frequency range and a 25-30 dBA low frequency attenuation.

Theoretical work combined with laboratory testing of a diesel engine

noise enclosure was reported June 1986.[6] The study tested various materials and properties of experimental enclosures seeking to achieve the greatest acoustic suppression. A honeycomb structure combined with a self-supported absorber produced the greatest noise attenuation. This study found a 5 dBA attenuation possible via engine design (stiffening various members). Further testing indicated a 15 dBA overall attenuation possible using lightweight acoustic engine enclosures.

However, any signature suppression effort must extend beyond a noise enclosure. An effective signature suppression program must approach the problem from a system level. Trade-offs of various potential methods must be evaluated to pursue an effective and viable suppression system. Design considerations should include many variables which may offer value. Some variables could include:

- a radiator for the entire system or for the engine,
- auxiliary equipment contribution to acoustic levels,
- auxiliary placement in or around the noise enclosure,
- exhaust silencer,
- radiator fan silencer,
- mechanical elements,
- orientation of components,
- increase engine wall thickness for increased noise attenuation, and
- use of a muffler to defeat low frequency noise prior to reaching noise enclosure.

3.4.4 <u>Rotary Diesel Disadvantages</u>.

As an internal combustion engine, the Rotary Diesel engine suffers from high noise emissions. Although the Rotary engine emits less overall noise and more high frequency noise than the standard diesel engines, it remains an internal combustion engine. Internal combustion generates low frequency noise. Low frequency noise, rather than high frequency, causes the greatest suppression difficulties. Aural suppression is a function of material mass and stiffness. Low frequency noise suppression requires significantly

increased enclosure mass and stiffness. The SLEEP requirements dictate low system weight in addition to signature suppression. In spite of the advances made over standard diesel engines, significant doubt exists in the Rotary Diesel engine's ability to meet the stringent noise and weight requirements concurrently.

An additional disadvantage of the Rotary engine evolves from its high exhaust temperature. Although the Rotary demonstrates higher efficiency than a standard diesel, the Rotary engine rejects more heat to the exhaust and less to the coolant. Meeting the thermal signature suppression specifications will necessitate cooling the engine exhaust. Cooling could take many forms (baffles, radiators, fans, etc.); however, all of these means increase the system weight.

The Rotary Diesel's development stage also presents difficulties for its application to SLEEP. Rotary Diesel engines are tranisitioning from the prototype to production stages in 60 kW to 1680 kW ranges. A SLEEP program incorporating this technology would necessitate down-sizing an immature technology in addition to the silencing effort.

3.4.5 Summary.

The Rotary Diesel engine technology option offers potential for the SLEEP program. However, meeting the stringent SLEEP requirements will require a full developmental system level effort. Rotary Diesel engines typically produce 75 - 80 dBA in operation. Laboratory testing indicates attenuation of perhaps more than 15 dBA may be possible using a noise enclosure. Industry estimates predict 35-40 dBA possible via a system approach to acoustic suppression.

With a full scale developmental program including development of a noise enclosure, the Rotary Diesel technology option may approach the SLEEP requirements. The technology offers a very low engine weight, small size, fewer moving parts, an adaptable logistics support system, and a unsurpassed manufacturing base. However, significant uncertainty exists in the ability

of the Rotary Diesel option to meet the SLEEP aural, thermal, and weight requirements concurrently.

3.5 Stirling Engine Technology.

Although the Stirling engine was invented at the end of the last century, it remained a laboratory test engine until only recently. Increased Government interest in alternative power sources initiated programs in automotive and space applications. These programs developed Stirling engines capable of meeting demanding performance requirements. Due to the developmental effort and the inherently quiet and efficient engine operation, scaled versions of the current Stirling engines possess potential for SLEEP applications.

Two different types of Stirling engines have been developed, Free Piston and Kinematic. The Free Piston Stirling engine has met with success in 3 kW generator set prototype testing and continues to offer potential for SLEEP, aa well as other applications. The Kinematic Stirling engine also offers potential for the SLEEP application due to the similarity in performance and power requirements, and the state of development resulting from the NASA/DOE Automotive Stirling Engine (ASE) Program.

3.5.1 Advantages of the Stirling Engine.

The major advantage of the Stirling for SLEEP applications results from the low aural and thermal operating signatures. This will allow the Stirling to meet SLEEP requirements without as much aural and thermal signature reduction equipment as internal combustion engines; hence less system weight. Other advantages of the Stirling include: high efficiency, potentially lower required maintenance, and multifuel capability.

The Stirling engine exhibits inherently quiet, efficient, and multifuel operation. As an external combustion engine, the Stirling engine circumvents the low frequency noise generation associated with internal

combustion engines. Testing, although limited, has demonstrated a maximum 10 dB noise differential under the worst case scenario: the Stirling at full power and a diesel engine idling. The standard Kinematic Stirling engine used for this comparison did not include a muffler.

The low thermal signature of the Stirling engine results from its high efficiency. Increased engine efficiency decreases the engine heat rejected to the atmosphere. Less heat rejection means a lower thermal signature and better fuel consumption.

The Stirling engine has demonstrated a thirty percent increase in fuel efficiency in both laboratory and prototype testing. The Stirling engine's high efficiency results partly from external combustion. Additionally, the Stirling engine efficiency is essentially load independent. Therefore, optimal fuel consumption and thermal signatures will not vary significantly with varying load levels.

Another inherent advantage of the Stirling engine revolves around the required maintenance level. Attributes such as: one ignitor, no catalytic converter, no particulate traps required for diesel operation, no oil or oil filter changes required, and minimal lubrication requirements provide the potential for lower maintenance costs, high reliability, and long life.

3.5.2 Current Development Status of the Stirling Engine.

Although the Stirling engine incorporated in a SLEEP generator set would not differ significantly from the currently developed designs in layout or arrangement, the engine would require scaling to meet the SLEEP power and weight standards. Scaling the current engines represents a considerable but not insurmountable engineering effort. The engine developers have already performed much of the conceptual design work; down-scaling the Kinematic engine and up-scaling the Free Piston engine. Although certain components will not scale, such as regenerators and heat exchangers, most components can be completely scaled without technological barrier.

The current Free Piston Stirling engine takes more than one form. Two engines have reached production stages, the 175 W propane engine and the 5 kW rice burning engine. Each of these engines exhibit high efficiency and no leakage of the working fluid. Although data on aural and thermal signatures were not available for these Free Piston engines, those of the Kinematic Stirling provide a reasonable estimate. Much of the work in this field continues to focus on applications under 1 kW: generator sets, heat pumps, etc. Current design efforts include using helium to replace air as the working fluid in developmental systems, developing a 25 kW spaced based powerplant (SP-100), and some scaling efforts. Much of the experience gained in bringing these engines to production will aid in developing SLEEP.

The Kinematic Stirling engine is in transition. The current Kinematic prototype engine progresses toward introduction into the industrial market. Currently, efforts with a major engine manufacturer focus on developing a manufacturing base to make the subsequent transition from prototyping to production.

Testing of the Kinematic engine has been limited at best. The DOE automotive engine contract calls for demonstration of performance requirements. This restriction limited the time available for endurance, reliability, and other life cycle testing.

In order to further establish life testing data and to penetrate the commercial marketplace, the developer has placed the Kinematic Stirling engine in US Postal Service utility vans/trucks. Anticipated design improvements resulting from prototype testing will be incorporated into the production design and subsequent manufactured engines. Current design improvements include the reduction of working fluid leakage paths and eliminating many fluid seals. As an experimental engine, the engine block was machined to allow assembly and disassembly. A production Kinematic Stirling engine will integrate much of the ducting into the engine block and eliminate many seals thereby reducing leakage of the working fluid.

Hydrogen, due to its low weight and availability, is the working gas in many Stirling engines. Military applications require a much less volatile substance due to the hostile battlefield environment. Helium would replace hydrogen as the working fluid in military applications. This eliminates the hazards associated with storing and transporting hydrogen. Studies have shown helium an acceptable alternative to hydrogen.

> "Helium is very well suited for Stirling engines if a slightly less compact engine (than hydrogen) is acceptable. Helium is inert, has a large enough molecular size to present an easier containment problem than hydrogen, and does not present any safety problems. The only difficulties with helium are that it is not as readily available as air and that, even though helium is presently in abundant supply, easily obtainable helium will be exhausted when the natural gas wells providing helium as a byproduct are exhausted."[7]

Extensive testing using four working fluids (air, methane, helium, and hydrogen) demonstrated that helium could serve as a viable substitute for hydrogen in the Stirling engine. Substituting gases other than hydrogen lowers the speed achieving maximum power due to increased pumping losses and reduced heat transfer. Hydrogen and helium attained nearly 48% efficiency at speeds near 1300 rpm and helium gave higher power than hydrogen at speeds above the design speed. Engine sizes, optimized for engine efficiency, for both hydrogen and helium were similar.[8]

A Stirling engine optimized for use with helium as the working fluid would require some modification to the current hydrogen optimized engine. However, these modifications could easily be made during the scaling redesign effort required for the development and manufacture of the Kinematic Stirling engine.

A further modification to the current Stirling engines would be necessary in order to meet the power quality requirement. An engine developer projects that by incorporating a flywheel, the requirements for the precise generator sets could be attained. This modification, plus others, should significantly reduce the control system complexity and increase reliability.

3.5.3 Stirling Technology Data.

As a result of design improvements from successive testing and modifications, the current Stirling engines exhibit the following key features:

	Free Piston	Kinematic
Power	175 W	60 kW
Volume	0.01 ft^3	10.2 ft^3
Weight	7 lbs	700.0 lbs
Efficiency	25%	38% @ 820°C

The Stirling engine offers significant saving potential in operational fuel requirements due to increased efficiency. For continuous operation as in the SLEEP application, performance levels exhibiting very high efficiencies could be expected. Although not explicitly specified in the SLEEP requirements, the efficiency and subsequent fuel economy of the Stirling engine will keep the mission weight at or below that of current generators.

Since the commencement of the NASA/DOE Automotive Stirling Engine Project, numerous hours of testing were logged on the various Kinematic Stirling engine designs, although long term tests such as life cycle and reliability tests have not been performed. Overall engine testing has resulted in the early generation engines undergoing in excess of 26,000 hours of testing, using sixteen total engines. Ten second generation engines have over 18,000 hours of testing. The most recent engine redesign underwent more than 600 hours of testing, using one engine.

Past failure modes have since been modified in subsequent engines and undergone successful retest. For example, piston rings and piston rod seals were once a primary failure point of the Stirling engine. However, several engine endurance tests of 1000 and 2000 hours have been completed without piston ring failures. Piston rings and piston rod seals have demonstrated successful operation in excess of 2000 hours, and the life goal of 3500 hours appears attainable. In addition, successful multifuel testing of 37

hours exhibited no major hardware failures during starting and operation using gasoline, diesel, and JP-4 without changes to control or combustor systems.[9]

3.5.4 Disadvantages of the Stirling Engine.

Although the Stirling Engine offers much promise for the SLEEP program, this technology faces certain difficulties; the major disadvantage being the lack of commercial experience with this technology. Although this prototype engine development involves a manufacturer, the technology has, as yet, not been manufactured and lacks industrial support. Many Stirling disadvantages derive from the state of development. In addition, the extensive redesign effort required to scale these engines to meet the SLEEP requirements presents another drawback not entirely unique to the Stirling. However, the redesign of a new technology is not without its problems. Another disadvantage resides in the unproven reliability of the current engine design. Although no SLEEP generator set has been developed, other technology options have much greater reliability testing and evidence.

The logistics support of the Stirling presents another major area of concern. This results from the immaturity of the technology and the lack of a broad industrial base. As a new technology, significant amounts of training, materials, and support would be required to field a Stirling SLEEP generator set.

Finally, a major disadvantage of the Stirling engine follows from its essentially unproven technology. Test and prototype engines have demonstrated reliability requirements in the laboratory, but life cycle and reliability testing require large amounts of data.

Another area of difficulty for the Kinematic Stirling engine involves leakage of the working fluid from the system. Leakage can occur in three paths: permeation through engine walls, permeation through dynamic seals, and permeation through static seals. Using helium should reduced engine wall leakage significantly. Leakage past the dynamic piston seal has shown

improvement in testing with hydrogen. Static seals have given the greatest difficulty; however, many leak paths will be eliminated in the production cast engine block. The hermetic seal of the Free Piston Stirling engine surmounts the leakage difficulty.

3.5.5 Summary.

Although, the Stirling engine does have some significant difficulties, the Stirling technology represents one of the few alternatives which appears capable of meeting all the SLEEP requirements. Further, any technology that meets or approaches the SLEEP requirements will be new, and in all probability, it will not have an extensive commercial support.

3.6 Fuel Cell Technology.

As recent as the early 1980's Fuel Cell technology remained bulky, rudimentary, and confined to research laboratories and high cost space applications. Since that time significant research efforts have been devoted to improving Fuel Cell technology. Industry efforts have produced rapid and dramatic improvements in Fuel Cell advancements and have extended the horizon of possible improvements. This increased potential is especially apparent in possible automotive applications. Industry support has focused on developing a Fuel Cell power system for automotive applications and utility power generation stations. As a result of these efforts, Fuel Cell technology now presents large potential for applications such as SLEEP.

3.6.1 Fuel Cell Advantages.

Many of the inherent qualities of the Fuel Cell power generation system make them ideal for SLEEP applications. Fuel Cells offer potential for a highly efficient and inherently signature suppressed power source. The potential power generation system which Fuel Cell technology offers SLEEP

will be a spin off from either of the automotive or utility development efforts.

Fuel Cell technology development efforts currently focus on five different kinds of Fuel Cells: Phosphoric Acid, Solid Polymer, Alkaline, Molten Carbonate, and Solid Oxide. Of these Fuel Cell technologies, the Phosphoric Acid Fuel Cell emerges as the nearest to commercialization. The outstanding characteristics of Phosphoric Acid Fuel Cells include: highly efficient operation, modular design, environmentally benign emissions, easily sited and mobile units, short installation lead time, and with the exception of the catalysts, the potential for low material costs.

3.6.2 Current Development Status of Fuel Cells.

A SLEEP generator set powered by one of the Fuel Cell technologies could greatly increase engine efficiency over other technology options. The average efficiency of an oil fueled central Fuel Cell station is 33%. Current Fuel Cells have exhibited 40% efficiency in laboratory tests. Should all the thermal energy of the Fuel Cell be fully utilized, an 80% efficiency level is theoretically possible.[10] Current estimates show a Fuel Cell propulsion system with a significant advantage in assumed efficiencies. The Fuel Cell shows nearly 2.5 times better efficiency than a spark ignition engine, and approximately 1.7 times higher than a Stirling engine system.[11]

Current predictions exalt the potential Fuel Cell technology offers for automotive applications. A generator set such as SLEEP also could reap the benefits of advancing Fuel Cell technology.

> "The interest in Fuel Cell technology for highway vehicle applications is rooted in its potential for very high energy efficiency, negligible exhaust emissions, and ability to utilize coal and/or biomass derived fuel sources."[12]

Although Fuel Cells offers high potential, the current development status prohibits near term application to systems such as SLEEP.

"Admittedly; however, the practical application of Fuel Cell technology for automotive highway vehicle use is probably at least fifteen years away."[13]

As a result of the Fuel Cell development status, this technology option incurs both high risk and high cost. However, the exceptional benefit potential of Fuel Cells should not be abandoned.

"The development of Fuel Cell technology for automotive highway transportation is thus both long-term and high risk by its very nature. The potential pay-off, however, in terms of petroleum and energy savings as well as environmental benefits, is tremendous."[14]

Specific areas needing development include performance and system cost.

"To compete successfully for future automotive highway vehicle application, Fuel Cell technology must be improved significantly in terms of performance and cost. Specific power (kW/kg) and power density (kW/l) must be increased and vehicle power plant cost must be reduced. These are challenging goals but appear to now be potentially feasible if continued technical progress can be made."[15]

3.6.3 Fuel Cell Technology Data.

Data on current Fuel Cell testing comes from field tests of utility power stations. Although not explicitly related to SLEEP, this testing demonstrates the developmental status of Fuel Cells. As reported in [16], program testing included 46 units tested. The program total results for the test showed approximately 600 total forced outages for the 46 units, primarily in the areas of electrical/electronics, mechanical controls, leaks, and mechanical components. Data for one representative field test unit are summarized below:

Average availability	63%
Average electrical efficiency	39%
Average total efficiency	74%

Succinctly, the field test demonstrated the technical feasibility of Fuel Cells, as well as the need for reliability and durability improvement.

3.6.4 Fuel Cell Disadvantages.

The primary shortcoming of the Fuel Cell involves the development status. Although an optimal SLEEP application, currently the Fuel Cell technology option offers very high cost and risk, with no near term production capability. System life specifically requires research and development. Currently, the cell life is too short. Operational life times of 25,000 to 40,000 hours are needed to offer reasonable costs.[17] Specific areas troubling Phosphoric Acid Fuel Cells include: precious metal requirements for electrode catalysts, slow start up due to high operating temperatures, and the relatively low specific power and power density.

3.6.5 Summary.

The Phosphoric Acid Fuel Cell technology option offers the greatest potential for SLEEP. This technology warrants more rigorous developmental effort and should be monitored for future developments. However, the technology still requires significant development before production of a SLEEP system can be considered feasible.

3.7 Other Technologies Important To SLEEP.

This section contains details of other technologies that relate to SLEEP.

3.7.1 Ceramics and Their Applications to Adiabatics.

The impetus of engine design today focuses on increasing engine efficiency. One method currently under development eliminates the cooling system of the standard diesel engine. This uncooled engine reduces system weight and parasitic power requirements. The net result increases the power

converted into useful work, hence efficiency increases. This uncooled engine has been labeled "adiabatic" due to its low heat rejection. The potential of reduced system weight holds some potential for a SLEEP application.

Adiabatics reduces the heat rejected by the engine through increased engine temperatures, better materials, and reclaiming exhaust heat energy. Engine efficiency projections predict an increase in excess of 30% using an adiabatic engine. [18]

An adiabatic engine exhibits very high temperatures in the combustion chamber. Without cooling, temperatures of the combustion chamber surfaces can exceed material limits and cause failure. Avoiding material failure requires new materials able to withstand the elevated temperatures of an adiabatic engine. As a result, interest in ceramics has grown. In addition to withstanding high temperature operation, ceramic materials offer several advantages in the areas of low friction, wear resistance, corrosion resistance and, in some cases, good insulation.

Three methods of introducing ceramics into engines include coatings, inserts, and monolithic ceramic engines. Although the ceramics are able to withstand elevated operational temperatures, heat transferred through the ceramics in long term operation can exceed the material limits of the cast iron housing. Testing of ceramic coatings and inserts has shown that temperatures can significantly exceed the housing material limits.

> "Due to the limited insulation capability of the thin ceramic coatings, very high temperatures were observed in certain areas of the cast iron structure of the engine and raised concern about the long term durability of this engine concept."[19]

In general, ceramic materials offer great potential to improving engine efficiency and for SLEEP applications. Significant work in areas of high temperature and high strength with good insulation, high fracture toughness, and overall reliability of ceramics require improvement. Although ceramic coatings and inserts have meet with some success, a monolithic ceramic engine still requires extensive research and development.

With the advent of ceramics able to withstand the operations of diesel engines, systems such as the adiabatic rotary Wankel engine will be possible. Currently laboratory testing of such an engine indicates up to 50% weight reduction, longer life, lower cost, fewer moving parts, and fewer failure modes than standard diesels with multifuel operation. However, development of the adiabatic Wankel engine still requires extensive development prior to reaching the prototype phase.

To summarize, ceramic materials offer a great potential in the development of adiabatic engines. The improved engine efficiency, decreased engine complexity, and reduced system weight can significantly improve engine performance. However, due to ceramic reliability difficulties, application of an adiabatic engine to SLEEP in the near term is doubtful. Currently, most of the work with ceramics centers around the diesel technology. However, as the ceramic technology advances, potential benefits of incorporating the successful ceramic processes into other technologies should also be considered.

3.7.2 Noise Enclosures.

In order to meet the aural and thermal requirements for near term SLEEP production, a noise enclosure will be necessary. The extent to which the enclosure must suppress signatures depends upon the technology considered. Generally, an enclosure for a diesel engine must provide suppression to a large degree where as a Stirling enclosure requires very little.

The SLEEP requirements for operation and maintenance will cause the most difficulty in enclosure design. Accessibility constraints require more doors than walls for any SLEEP enclosure. In addition, all the doors must necessarily be of relatively small size and shape yet include HFE and Manpower and Personnel Integration (MANPRINT) design considerations for operation of switches or the wearing of protective clothing. Depending upon the technology considered, a floor may be required.

Concurrent with the development of a SLEEP generator set must be the development of an enclosure. Trade-offs such as increasing engine wall thickness and decreasing enclosure walls should be considered. Additionally, problems of vibration and absorbtion need addressing. High frequency noise presents a relatively minor problem in suppression, but does cause difficulties in sealing efforts. Low frequency noise, if not fully suppressed using a muffler, presents a much greater suppression problem for a noise enclosure.

Discussions with industry representatives indicate a SLEEP panel, 2-3 lb/ft^2, could attenuate noise up to 35 dB. The estimates project a program likely to require a year in development.

Laboratory testing has demonstrated the feasibility of a lightweight, stiffness controlled enclosure. However, significant challenges in the areas of penetration, sealing, and vibration isolation exist. Testing consisted of varying parameters for ten different panel configurations. The four parameters considered were: panel length, air space, materials (steel, aluminum, one inch honeycomb, two inch honeycomb), and material thickness.

> "On the basis of high stiffness to mass ratio, the two-inch honeycomb panel appears to be the best choice. The additional width of honeycomb core adds little to the mass and greatly to the stiffness. Stiffness of the honeycomb composite is dependent only on the stiffness of the facing sheets and the distance of their separation. This panel experiences far fewer resonances than the others. Not only are there fewer resonances to be damped, but there is also less chance of panel and standing wave resonances coinciding. Another advantage of the honeycomb panels is the apparent lack of effect of air stiffness on them. They can be placed very close to the engine side walls to avoid standing wave formation at low frequencies. "[20]

The total estimated area for an enclosure consisting of two inch honeycomb with a self-supporting absorber approaches two square meters. The total mass of such an enclosure for an 8 kW generator set would be 47.8 lbs/21.7 kg [21]. However, one disadvantage of the honeycomb material involves their high costs as compared to other sound attenuation materials.

Testing at another facility successfully demonstrated the use of Mylar and polyurethane foam with steel facings to attenuate noise [22]. The addition of stiffening members also increased attenuation 5 dBA. A diesel vehicle transmission enclosure with the interior surface lined with one inch thick, 2 lb/ft^3 polyurethane foam with a 0.0005 inch thick aluminized Mylar facing, was covered with a 220-gauge (0.031 inch) perforated steel sheet (51% open area) successfully suppressed noise levels to the required Occupational Safety and Health Administration (OSHA) levels. Although the program requirements specified acoustic levels much greater than those of SLEEP, this program successfully demonstrated acoustic suppression using materials other than those tested in [23].

The level of effort required in developing a SLEEP acoustic enclosure directly relates to the technology option selected. An enclosure for a turbine engine represents an extreme in acoustic enclosures. The required airflow through a turbine, and the associated noise, would require such suppression efforts that this technology option was eliminated. A diesel engine would require an enclosure able to significantly attenuate noise. This noise enclosure would require a significant development program. A Stirling engine would require a very modest enclosure due to the inherently signature suppressed operation. Development of such an enclosure is considered minor relative to the diesel enclosure. Fuel Cells presumably would not require an acoustic enclosure. However, assessment of Fuel Cell signatures should be conducted as the technology matures to a production level.

3.8 Technical Assessment Summary.

Three technology options offer the potential to meet the SLEEP requirements. They include Rotary Diesel with noise enclosure, Stirling, and Phosphoric Acid Fuel Cells. A comparison of the projected capabilities of the different technology options may be seen in Table 3-3. Each alternative has an associated risk and pursuit of one option over another

necessarily involves trade-offs. An analysis of the risk associated with each technology option and an evaluation of the subsequent trade-offs are detailed in the following section.

TABLE 3-3

COMPARISON OF TECHNOLOGIES - PROJECTED CAPABILITIES

PARAMETER	REQUIREMENT	TECHNOLOGY			
		Diesel	Rotary	Stirling	Fuel Cell
Power	10 kW	10	10	10	10
Weight	650 lbs		**	*	*
Volume	30 ft^3	*	**	*	**
Fuel(s)	Diesel	Diesel	**Multifuel**	**Multifuel**	**Multifuel**
Aural Signature	0 dB @ 100 m			**	**
Thermal Signature	+/- 4°C			**	**
Maturity		Production	**Laboratory**	Prototype	**Laboratory**
MTBF	600 hrs	*			**

* indicates expected to meet requirement
** indicates technology expected to exceed requirement, area of great advantage
Bold & indicate current areas of concern

4. FEASIBILITY ANALYSIS

The Feasibility Analysis takes the technology options identified in the Technology Assessment and evaluates each alternative from a broader perspective. This analysis addresses issues such as system effectiveness, technology maturity, and the risks involved in pursuing each alternative. The analysis evaluates the technology options to establish the alternative which offers the Army the most effective performance at the lowest risk. Further, the Feasibility Analysis compares the necessary trade-offs associated in pursuing each technology alternative. Therefore, this Feasibility Analysis is divided into three parts: an Alternative Evaluation, a Risk Assessment, and a Trade-off Study.

Before describing the conduct of the Feasibility Analysis it should be made clear that the evaluations and analyses which follow are based on relative comparisons of the technology alternatives and not based on absolute comparisons or comparisons to a given baseline.

4.1 Alternative Evaluation.

The competing SLEEP alternative technologies must be evaluated and compared in order to recommend the most promising technology or technologies for development. This comparison of alternatives comprises three discrete steps. The first step identifies the evaluation criteria used to judge the competing alternatives. The second step assigns weighting factors to these evaluation criteria. The final step evaluates the alternatives using the weighted criteria.

4.1.1 Alternative Evaluation Criteria.

The evaluation criteria identified to evaluate the SLEEP alternatives separate into two fundamen' categories - system parameters and technology standards. The system parameters include hardware characteristics that influence mission success and system effectiveness, such as reliability,

weight, electrical performance, and fuel efficiency. The system parameter evaluation criteria were selected based on system requirements contained in the ROC and O&O Plan. Technology standards include factors that provide information regarding the technology itself, such as technology maturity, acquisition cost, and system complexity. The technology standards evaluation criteria are common factors used to evaluate any technology proposed for development. Technology standards include some of the same factors used to evaluate technical, cost, and schedule risk.

SYSTEM PARAMETERS

As a basis for comparison, all system parameters were initially identified as quantitative parameters. However, data for all parameters could not be obtained for all alternatives. This led to a decision to further divide the system parameters into two sub-categories, quantitative and qualitative. Characteristics evaluated using actual data or estimates are quantitative parameters. Qualitative parameters describe those characteristics for which data or estimates do not exist.

The evaluation criteria were developed using SLEEP system requirements and systems acquisition documentation. The system parameters primarily derive from user requirements contained in the ROC and the O&O Plan.

QUANTITATIVE SYSTEM PARAMETERS

These five system parameters, aural signature, reliability, weight, thermal signature, and volume were chosen as the quantitative factors for two reasons. These parameters represent the most important factors to a successful SLEEP development program, and with the possible exception of aural and thermal signatures, these factors represent specifications standard to most manufactured products. The quantitative system parameters include the following:

- Aural Signature. Minimum distance in meters at which the operating engine or power conversion equipment can be detected by the sound produced.

- Reliability. Mean time between failure of the system is measured in operating hours.

- Weight. Dry weight of operable system and accessories measured in pounds.

- Thermal Signature. Temperature difference between operating engine or power conversion equipment and the ambient temperature measured in degrees Celsius (^{o}C).

- Volume. Volume of operable system and accessories measured in cubic feet.

QUALITATIVE SYSTEM PARAMETERS

The quantitative group of system parameters include factors for which complete quantitative data was not available for all technology alternatives. Therefore, based upon research and the data obtained, the parameters listed below represent sub-categories for a qualitative evaluation. The values assigned to these qualitative system parameters reflect relative rankings of the technologies rather than actual performance of the technologies. The qualitative system parameters include the following:

- Electrical Performance. Transient response to load variation.

- Power Quality. Steady-state variation of voltage and frequency.

- Fuel Requirements. Type of fuel required (Diesel, JP, etc.).

- Maintainability. Mean time to repair the system including scheduled and unscheduled maintenance measured in hours.

- Fuel Efficiency. Fuel consumed per unit of electric power produced.

- High Altitude Operation. Reduction in peak power associated with increased altitude.

- Low Temperature Operation. Time to start and produce power at temperatures below $-25^{o}F$.

- System Life. Operating hours before system retirement.

TECHNOLOGY STANDARDS

Technology standards also reflect qualitative rather than quantitative measures of a system's suitability for development. These standards reflect relative rather than actual system merit. The technology standards were

primarily derived from Risk Assessment documentation. Technology standards include the following:

- Technology Maturity. Commercial availability of the technology.
- Operation and Maintenance Costs. Labor, POL, and spare and consumable parts costs necessary to operate and maintain the system.
- Acquisition Costs. Research, development, test and evaluation, and production costs.
- System Complexity. Number of subsystems, number of components, and the number of subsystem interfaces.

4.1.2 Weighting The Evaluation Criteria.

After identifying the evaluation criteria for the technology alternatives evaluation, a weighting factor must be assigned to the individual criterion. Weighting the evaluation criteria entails assigning a number to each system parameter and technology standard. The importance of the particular parameter or standard to mission success, system effectiveness, or in meeting the SLEEP requirement form the basis for this process. Ranging between one and five, the weighting factors were assigned using the requirements priority listed in Section 2 of this report and through discussions with subject matter experts.

The weighting scale used in this analysis is defined below:

1	Desirable
2	Important
3	Very Important
4	Extremely Important
5	Essential

Note that these weighting factors indicate the worth of one parameter or standard relative to another in mission success or system effectiveness.

Weighting factors for the system parameters and technology standards are shown in tabular format. Table 4-1 shows the weighting factors for the quantitative system parameters. Table 4-2 presents the weighting factors for the qualitative system parameters. Similarly, Table 4-3 displays the weighting factors for the technology standards. The weighting factors were assigned to the system parameters and technology standards based on the requirements priorities contained in the ROC and O&O Plan.

TABLE 4-1. WEIGHTING OF QUANTITATIVE FACTORS.

Aural Signature	5
Reliability	5
Weight	5
Thermal Signature	4
Volume	3

TABLE 4-2. WEIGHTING OF QUALITATIVE FACTORS.

Electrical Performance	4
Power Quality	4
Fuel Requirements	3
Maintainability	3
Fuel Efficiency	2
High Altitude Operation	2
Low Temperature Operation	2
System Life	1

TABLE 4-3. WEIGHTING OF TECHNOLOGY STANDARDS.

Technology Maturity	5
Operation and Maintenance Costs	4
Acquisition Costs	3
System Complexity	3

4.2 Technology Alternative Comparison.

The preceding processes, selecting the evaluation criteria and assigning appropriate weighting factors, have both been independent of the technology alternatives. The following comparison necessarily depends upon the particular technology option under consideration.

After assigning weighting factors to each parameter or standard, the evaluation of each technology alternative proceeds. The technology alternative comparison involves four processes. The result yields a total quantitative value comparing the alternatives. An example comparison will aid in this discussion and may be seen in Table 4-4. This example reflects data from the quantitative system parameter comparison of the diesel technology option. Although not explicitly represented, the table may be viewed as two halves; the left half being technology independent, while the right half (the grade, score, and rating) are technology dependent.

The first process evaluates a particular system parameter or technology standard based on the system performance and assigns a grade, in this case a parameter grade. The grade is a numerical value based on a scale between 0.0 and 0.9; the higher the system performance, the higher the grade. In the example the parameter grade for reliability is 0.82.

TABLE 4-4. SLEEP ALTERNATIVE COMPARISON EXAMPLE.

SYSTEM PARAMETER	WEIGHTING FACTOR	TECHNOLOGY ALTERNATIVE	
		PARAMETER GRADE	PARAMETER SCORE
AURAL SIGNATURE	5	0.27	1.35
RELIABILITY	5	0.82	4.10
WEIGHT	5	0.11	0.55
THERMAL SIGNATURE	4	0.60	2.40
VOLUME	3	0.63	1.89
		ALTERNATIVE RATING	10.29

In the second process, a parameter score develops as the product of the parameter grade and the previously assigned weighting factor, in the example for reliability, 0.82 x 5 = 4.10, the parameter score. A vertical summation of the individual parameter scores determines the alternative rating in the third process. In the example, the alternative rating is 10.29. Since there are three comparison categories, two system parameters and the technology standard, three alternative rating values have been determined for each technology option. The final comparison process combines the three alternative ratings to produce a technology total for each technology alternative. Table 4-5 presents the actual totals for the three technology options as well as the individual alternative ratings. The data, evaluations, grades, weighting factors, and scores of the system parameters and the technology standards are contained in Appendix B. The data and information used to make these determinations was obtained from technical reports and journal articles examined during the literature review

TABLE 4-5. RATINGS OF TECHNOLOGIES BY CATEGORY.

CATEGORY	ROTARY	STIRLING	Fuel Cell
QUANTITATIVE PARAMETER	9.8	13.3	17.1
QUALITATIVE PARAMETER	16.9	16.7	12.5
TECHNOLOGY STANDARD	10.3	9.3	3.9
TECHNOLOGY TOTALS	37	39.3	33.5

and from information gathered during visits to research and development companies.

To review, a grade from 0.1 to 1.0 is assigned based on the performance of an alternative in a parameter or standard. The score is the product of the grade and the weighting factor for a parameter or standard. The rating sums all system parameter or technology standard scores for a single alternative.

4.2.1 Alternative Ratings Discussion.

As shown in Table 4-5, all the technology ratings match very closely. The Rotary and Stirling technologies differ by 2.3 points, with the advantage to Stirling. The Stirling rated highest with a technology total of 39.3, the Rotary followed closely with a total of 37, and the Fuel Cell rated the lowest of the three alternatives with a technology total of 33.5. Greater insight into the meaning of these numbers may be seen within the categories.

The Rotary and the Stirling are fairly evenly matched in all of the categories. The lower score of the Rotary in the quantitative parameters is mainly attributable to its high noise and thermal signatures. The higher scores of the Stirling and the Fuel Cell reflects the significantly lower signatures. The difference between Fuel Cell and the Stirling results from the higher reliability and still lower signatures of the Fuel Cell.

In four of the eight qualitative parameters, the Rotary and the Stirling technologies received identical grades. The electrical performance and power quality of each were judged equal based upon the smooth operation of both technologies. Both engines exhibit low temperature operation and multifuel capabilities. In the four areas which differed, the Stirling scored higher in fuel efficiency, high altitude operation, and system life due mainly to its external combustion design. The Rotary performed better in maintainability due to its simplicity. The Fuel Cell grades reflect the current predictions for the performance of this developmental technology.

The results of the technology standards grading indicate that the Rotary scored the highest because of commercial use of a gasoline version of this technology. The Stirling, although ready for commercialization, has not been produced commercially and as a consequence scored lower than the Rotary. The lack of development and high projected costs of Fuel Cell technology are indicated by the poor showing in this category. As the most mature technology, the strong showing of the Rotary was not unexpected.

The results of this technology alternatives comparison indicated that the Stirling technology offers the best potential for the SLEEP program. This evaluation, combined with the following Risk Assessment and Trade-off Study, determines a technology recommendation for SLEEP.

4.3 Risk Assessment.

Evaluating the risk associated with each technology alternative required the identification of system characteristics able to describe the

development and deployment risks. Accordingly, these system characteristics include:

- Technological Maturity
- Tests Performed
- Independence from other Technologies
- Technical simplicity
- Similarity to Army Systems
- Similarity to Industrial Systems

These characteristics were selected because they directly impact technical, cost, and schedule risks associated with the systems development and acquisition programs. Technological maturity refers to the state of development of a technology; the less developed the technology, the greater the risk. Tests performed measures risk reduction achieved through testing. Independence from other technologies indicates the extent to which the technology alternative relies upon other emerging technologies. The greater the reliance on developing technology the greater the risk. Simplicity defines risks associated with the equipment configuration. A system with numerous parts or subsystems, complex internal or external interfaces, or difficult operational requirements carries an associated risk to system development. Similarity to Army systems measures risk involved with integrating an operational system into the Army's existing personnel and equipment structure. Similarity to industrial systems indicates the decrease in risks associated with the commercial use of a technology.

Table 4-6 presents the risk contribution of each characteristic for the three SLEEP technology options. Each technology option was assessed a numerical value for each characteristic indicating the contribution to the overall level of risk on a scale from low risk (0.0) to high risk (0.9). The numerical values presented relative risk evaluations among the technologies as opposed to absolute risk values. The risk assessed in each case was based on the information gathered during the Technology Assessment. Weighting factors or multipliers were not assigned to the characteristics because the contribution to overall risk was thought to be the same for all

TABLE 4-6 RISK ASSESSMENT

RISK AREA	TECHNOLOGY		
	ROTARY	STIRLING	Fuel CellS
Technological Maturity	0.3	0.5	0.8
Tests Performed	0.2	0.3	0.6
Independence from other Technologies	0.4	0.2	0.8
Technical Simplicity	0.4	0.3	0.2
Similarity to Army Systems	0.5	0.5	0.8
Similarity to Industry Systems	0.2	0.4	0.7
	Scale: 0.0 - 0.9 (low risk - high risk)		

of the characteristics. The following discussion explains the rationale for the risks assessed.

Technological Maturity - The contribution to risk from technological maturity was lowest for the Rotary technology as a result of its development level. Gasoline Rotary engines have been produced for several years and the

subsequent operational experience reduces the level of risk. The risk contribution of the Stirling technology was moderate because it lacks extensive operational life cycle testing. As this technology matures, the risk level should decrease significantly. The Fuel Cell technology risk contribution also results from its level of development. Since the Fuel Cell is currently a laboratory test device, a high risk contribution may be attributed to this technology alternative.

Tests performed - As stated above, the contribution to risk from testing decreases as the amount of successful testing increases. The minimal risk contribution to the Rotary engine results from gasoline operation in automobiles. In addition, the production plans for this engine indicate that thorough tests have been performed. The risk contribution of the Stirling in tests performed is considered small, but not small as the Rotary. The Stirling engine has been successfully demonstrated through laboratory and prototype engine tests. The Fuel Cells relatively high risk level stems primarily from its technical immaturity and relatively incomplete laboratory testing.

Independence - The relatively high noise generation of the Rotary engine requires a major acoustic enclosure development effort. Although noise attenuation technology is not new, the technology continues to evolve and meeting the SLEEP requirements may push the technology envelope. This dependence upon noise enclosure technology results in a low to medium risk component for the Rotary technology alternative. Conversely, since the Stirling displays inherently signature suppressed operation requiring only a minor enclosure, the risk contribution from technology dependence is low. In addition, all technological barriers to development of the Stirling have been overcome. Again a consequence of the development level and the required development of internal components, the technology dependence risk contribution is high for the Fuel Cell technology option.

Technical Simplicity - The risk contribution from system simplicity for all alternatives is quite similar. Although the Rotary engine is very simple with relatively few moving parts, the requirement for the noise

enclosure significantly increases the Rotary SLEEP system complexity. Developing an enclosure consisting of mostly doors for access rather than walls accords a significant increase in system complexity resulting in a medium risk contribution. The risk contribution from system simplicity for the Stirling is slightly lower that the Rotary, yet not negligible as a consequence of the auxiliaries and associated connections within the engine. The component of risk from system simplicity is lower still for the Fuel Cell because it has very few moving parts.

Similarity to Army Systems - The contribution to risk from similarity to Army systems for the Rotary and Stirling are both medium. Although similar as operating units and in configuration - both being heat engines, one internal combustion and one reciprocating - the similarity to existing Army systems is external. Internally each system contains differences which cause a medium risk component. A Fuel Cell SLEEP generating system presents very new and different power generation which causes the risk contribution to be quite high in similarity to Army systems.

Similarity to Industry Systems - The final risk area, similarity to industry systems, addresses the possibility that a system may be new to the Army, but familiar to industry. Not surprisingly, the component of risk for the Rotary is low because of its commercial (automotive) applications. Since other engines and development efforts exist within industry, the risk contribution from Stirling engine is lower than in the preceding area, but higher than the Rotary. Likewise, the contribution for the Fuel Cell decreases in this category because of the applications of this technology in the past and projected application in the future.

This Risk Assessment primarily considers technical risk, although cost and schedule risk are considered as they relate to technical risk. Summing the contributions to overall technical risk of each risk component provides an indication of technical risk for each option. The summation follows: Rotary - 2.0, Stirling - 2.2, and Fuel Cell - 3.9.

Fuel Cells present the greatest technical risk, due to immaturity and

dependence on other technologies. Development of internal components are necessary to meet requirements using this technology. Schedule risk increases with dependency, relatively little testing, and disparity to current military and commercial systems. The necessary testing and systems integration will require time, especially if problems occur. The Fuel Cell cost risk is considered high due to the relatively high technical and schedule risk.

The technical risk associated with the Rotary and the Stirling are nearly the same and markedly lower than that of the Fuel Cell. In the case of the Rotary, the primary contributors to the technical risk include simplicity, dependence, and differences from current systems. The technical risk is considered low to medium. Schedule risk is also due to technical dependency and differences from current systems and is considered low, as is the cost risk.

The Stirling is also considered to have a medium to low technical risk due to technological maturity and lack of similar systems in military and commercial applications. The schedule risk is considered medium due to possible delays associated with redesign and preparing the engine for production. Cost risk is considered low to medium based on the few technological barriers faced by this technology.

This assessment, in conjunction with the preceding comparison and the following Trade-off Study, aids in evaluating which technology option offers the optimal procurement potential.

4.4 Trade-off Study.

Since no alternative is without its inherent limitations, this analysis evaluates the trade-offs considered in selecting the recommended alternative for SLEEP.

4.4.1 Fuel Cell.

Selecting the current Fuel Cell technology for SLEEP procurement will incur serious trade-offs. Potential high performance benefits must be balanced against the high cost and long term schedule of developing this immature option. In addition, the technical risks and costs involved must be compared to the potential performance. Also, the affects on interoperability, logistics, training, and MANPRINT must also be considered.

4.4.2 Rotary.

The primary trade-off made in selecting the Rotary technology for SLEEP involves the technical risk of meeting performance requirements. This alternative may fail to meet some SLEEP requirements. To meet the signature suppression requirements, the weight specification may be exceeded. Conversely, meeting the weight limit will necessitate less signature suppression. However, if this degradation in performance can be tolerated, the Rotary technology presents, by a small margin, the lowest risk alternative. The expense and time required to field a Rotary SLEEP generator set is expected to be less than other technology options. However, the Rotary will impact logistics; training; MANPRINT; Rationalization, Standardization, and Interchangability (RSI).

4.4.3 Stirling.

The trade-off in selecting the Stirling technology option also involves performance. Selecting the Stirling alternative appears to facilitate meeting the SLEEP performance requirements at the expense of development time and cost. The Stirling technology will require more time and cost to field an operational system than the diesel option. The Stirling also affects logistics, training, MANPRINT, and RSI.

Further trade-off discussion is included in the Sensitivity Analysis presented in Section 5.

4.5 Conclusion.

Based on the results of the Alternative Evaluation, Risk Assessment, and Trade-off Study the Stirling engine emerges as the best alternative to meet SLEEP requirements. The Stirling appears able meet the requirements, presents manageable risks, and acceptable trade-offs.

5. SENSITIVITY ANALYSIS

Throughout this study two fundamental assumptions were considered as a baseline. One of these assumptions dictated that a system meet the program requirements to be considered for SLEEP. This Sensitivity Analysis examines the impact of this assumption upon potential SLEEP systems.

5.1 Relaxing the Requirements.

Relaxing the SLEEP requirements necessitates an examination of those requirements and an understanding of how they interrelate. Seven requirement areas have been identified as offering potential for relaxation. They include:

- Noise
- Weight
- Thermal
- Volume
- Fuel
- Power
- Reliability

The first four parameters lend themselves to quantitative analyses to establish trade-off guidelines. For example, a relationship between noise and weight can be estimated; "X" increase in noise suppression requires a "Y" increase in weight. The later three parameters lend themselves to qualitative analyses.

5.1.1 Quantitative.

Relaxing the noise requirement, allowing SLEEP to be louder, would require a smaller signature suppression effort. Since noise and weight are directly coupled, a result of this action would decrease the system weight. Similarly, relaxing the weight requirement, allowing SLEEP to be heavier,

would increase the signature suppression capabilities of the SLEEP system. Easing the thermal specification, allowing SLEEP to emit more heat, impacts the SLEEP auxiliaries. Decreasing this requirement could decrease the weights of auxiliary equipment (i.e. fans, radiators,...) which in turn could reduce the noise generated (reducing the cooling fan size). Relaxing the volume requirement could increase the noise attenuation due to better source isolation and suppression potential.

5.1.2 Qualitative.

Relaxing the fuel requirement would enable engines which use fuels other than diesel to be considered for SLEEP, i.e., a gasoline engine. Easing the power specification hinges on the belief that generator sets are typically overpowered. By allowing a smaller generator to fill the SLEEP mission, a decrease in weight, volume, and noise generation might be possible. Finally, relaxing the reliability specification would tend to benefit developmental engines thus enabling shorter production schedules.

5.2 Technologies.

Relaxing the SLEEP requirements directly impacts the technologies available for SLEEP. In addition to Phosphoric Acid Fuel Cells, Rotary Diesel Engines, and the Stirling Engines, technologies previously rejected may be able to meet a relaxed SLEEP requirement. To aid in this analysis the technologies have been separated into two groups, Existing Technologies and Emerging Technologies.

Two technology alternatives previously eliminated offer SLEEP potential under a relaxed requirement, the Diesel and Brayton engines. Both of these technologies exist in the sense that the technology necessary to produce these engines is currently available.

In contrast to the Existing Technology group, the Emerging Technology group requires significant developmental efforts to bring a SLEEP engine

generator into production. Three technologies fall under this category: Stirling Engines, Phosphoric Acid Fuel Cells, and the Rotary Diesel Engine. When considering the seven relaxation parameters within the context of Fuel Cells, the immaturity of this technology renders the parameters insensitive. Based on the immaturity of the Fuel Cell technology, relaxing the SLEEP requirements yields no significant benefit in developing a Fuel Cell powered SLEEP system. Therefore, due to the immaturity of the technology, Fuel Cells may be eliminated from further consideration as a near term technology alternative for SLEEP.

As expected, each viable technology alternative offers distinct advantages. As a result, relaxing various parameters will exhibit disparate results among the technologies. Table 5-1 displays the qualitative benefit expected in each technology with the relaxation of the seven parameters. Dashed lines indicate the technology alternative would benefit little from a relaxation of the requirements.

5.3 Noise versus Weight.

An examination of Table 5-1 yields a coupling within the seven parameters, noise and weight. These requirements are naturally coupled and mutually exclusive within the technologies considered, i.e., increasing the noise attenuation necessitates an increase in weight. As a result of this relationship, the stringent noise and weight specifications place the greatest restriction on SLEEP. The prominence of these requirements suggest a quantitative analysis could aid in exploring the relationship between noise and weight.

Noise and weight data were collected for the four technologies shown in Table 5-1. When plotted as in Figure 5-1, the relationship between noise and weight may be extracted. Figure 5-1 demonstrates the development progression between a standard or current engine, and that of a signature suppressed engine. As expected, noise and weight are inversely related. As the figure shows, the suppressed Diesel Engine set demonstrated a

TABLE 5-1 BENEFITS OF RELAXING REQUIREMENTS

REQUIREMENT RELAXED	BENEFIT - EXISTING TECHNOLOGIES		BENEFIT - EMERGING TECHNOLOGIES	
	DIESEL	BRAYTON	ROTARY	STIRLING
NOISE	Reduce weight, Use of currrent gènerator set with modifications	Reduce weight	Decrease suppression effort, Reduce weight, Use current engine	Reduce weight, Use current Stirling engine
WEIGHT	Increase noise attenuation	Increase noise attenuation	Increase noise attenuation	Decrease suppression effort
THERMAL	Decrease auxilliary weights and noise generation, use current generator sets	Reduce weight	Decrease suppression effort	----
VOLUME	Possibly increase noise attenuation	Possibly increase noise attenuation	----	----
FUEL	----	----	Gasoline engine	----
POWER	Decrease engine size and system weight, increase noise attenuation	Decrease engine size and system weight, increase noise attenuation	Decrease engine size and system weight, increase noise attenuation	Greater down-sizing effort
RELIABILITY	----	Enable use of current engines	Decrease development effort required	Decrease development effort required

---- Indicates no significant benefit expected

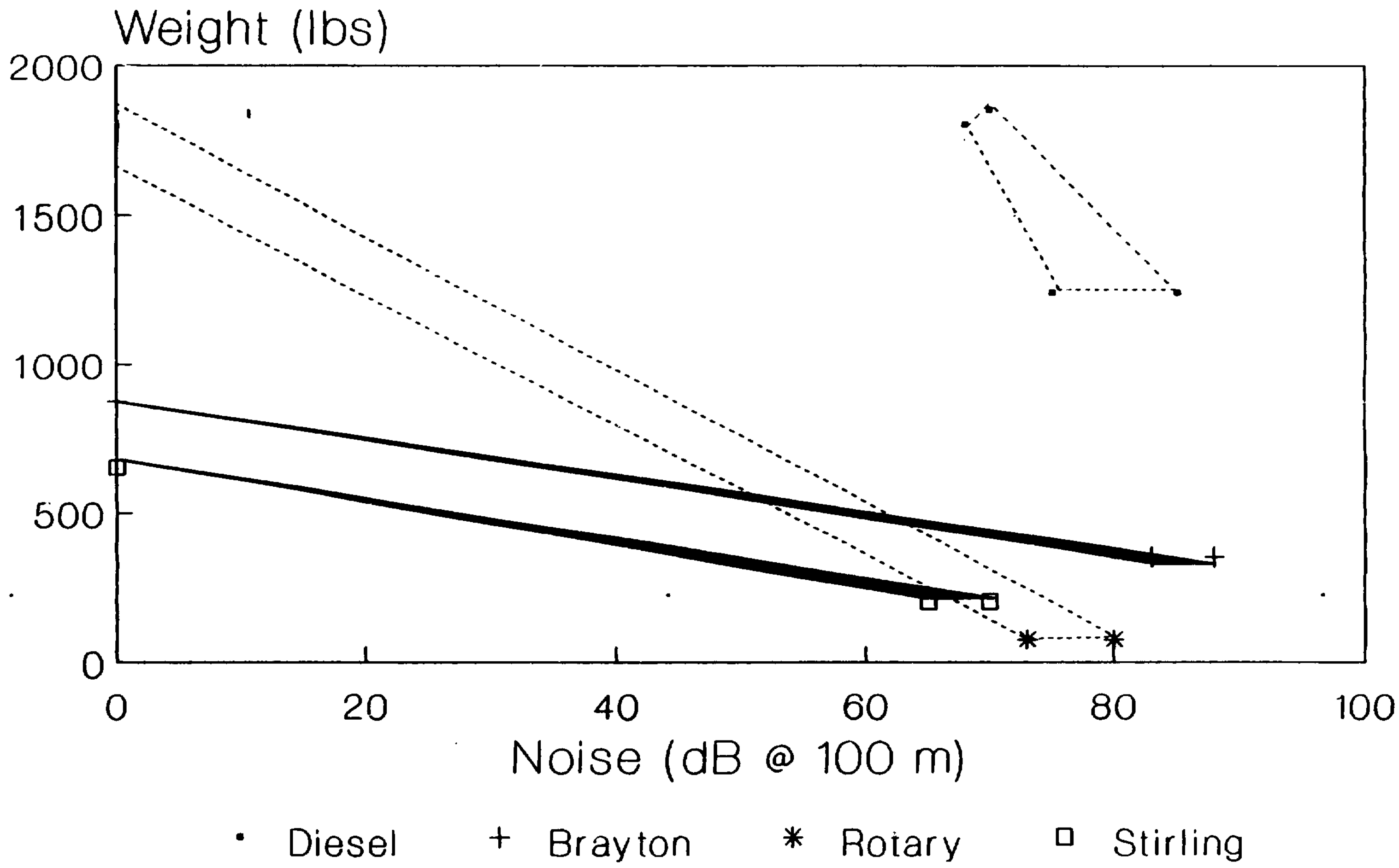

Figure 5-1. Noise and Weight Comparison

surprisingly large increase in weight for a relatively small decrease in acoustic level (50:1). The Gas Turbine (Brayton) engine driven set demonstrated a much more gradual relationship (5:1).

Although actual data exists for the existing technologies, not all data points could be gathered for the emerging technologies; therefore, the signature suppressed engine data was interpolated. As may be anticipated in an internal combustion engine, the Rotary Diesel exhibits a high unsuppressed signature. However, with the low weight of this engine and the inherent advantages of the rotary engine, significant advances in suppression could be achieved. The interpolated trend line shown exhibits a slope similar to that of the standard diesel. At the unsuppressed weight of the standard diesel, the rotary diesel could emit one quarter the acoustic level of the standard diesel engine, and approach complete silencing (at 100 meters) with the equivalent weight of the suppressed diesel engine.

To interpolate data for signature suppressed Stirling and Rotary Diesel engines required an approximation of scaled engine weights. Both the current Kinematic Stirling and Rotary engines produce 60 kW of power. A 10 kW SLEEP necessitates a significant scaling effort in each case. Data from standard (unsuppressed) engines over similar power ranges was used to estimate the weights of scaled (10 kW) Stirling and Rotary engines. The data for the standard diesel engine power series and the proportional approximations of the engines are shown in Figure 5-2. This estimate makes use of the similarity in power produced and fuel consumed of the Kinematic Stirling and standard diesel engines. Although developed around the Kinematic Stirling, this analysis extrapolates these power and weight estimates to the Free Piston engine.

Using the approximated scaled engine weights and analogies to existing technologies, the suppressed engine characteristics of the Stirling and Rotary engines was interpolated. The Stirling and Brayton engines are both continuous combustion engines. Utilizing this similarity, the suppressed

characteristics for the Stirling were interpolated from the Brayton engine data. Likewise, the suppressed Rotary characteristics derive from the standard Diesel data.

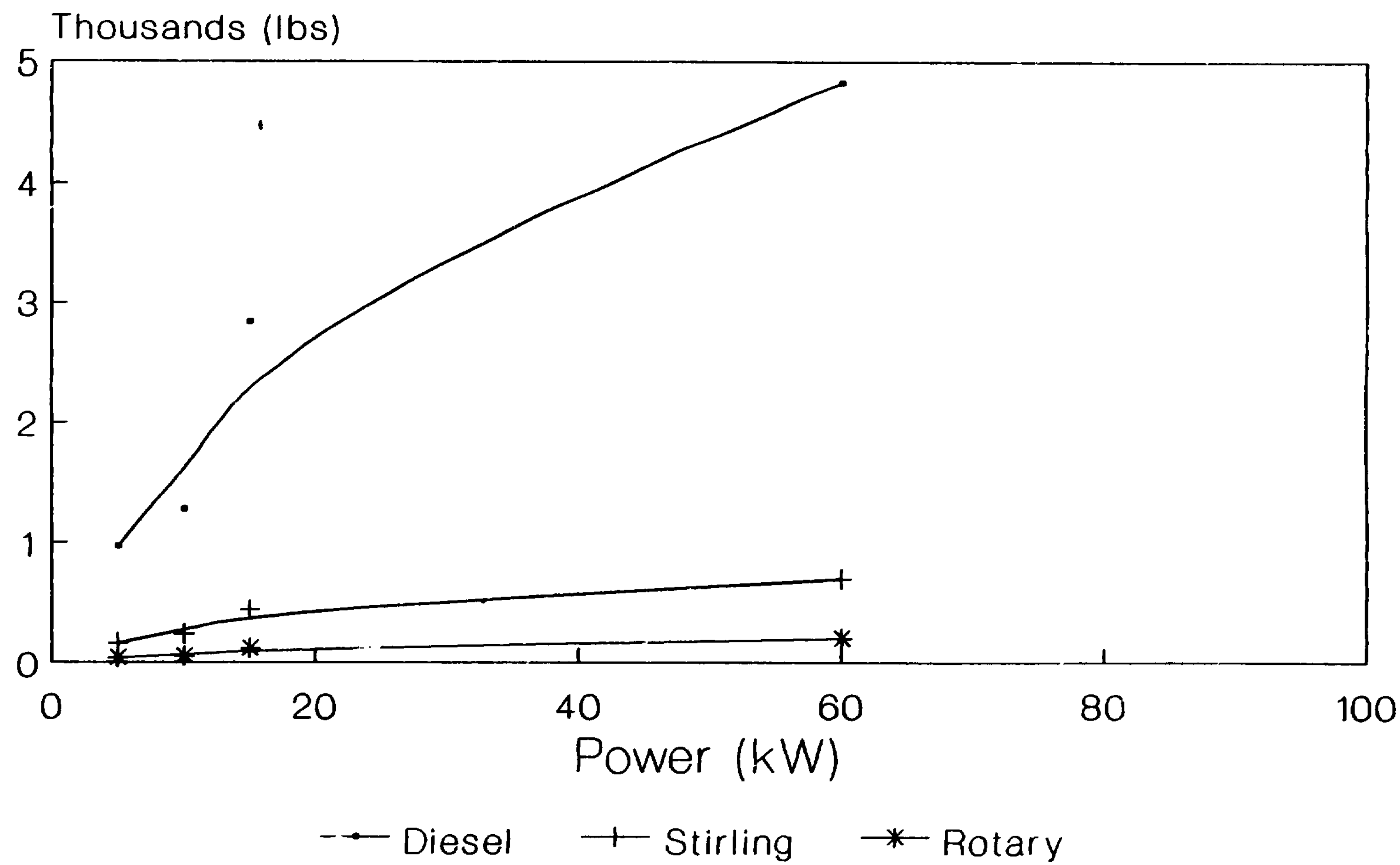

Figure 5-2. Weight Interpolation

5.4 Context and Perspective.

Part of a Sensitivity Analysis includes placing the information obtained from the study in the proper context and perspective. Although some information is based upon interpolated data, this analysis is useful for trend approximation.

First, the standard diesel data involved a kit addition for silencing, not an engine rework. In spite of this, the noise reduction and weight increase trade-off ratio is quite small. This trend indicates that the noise emitted by the diesel set will not be readily suppressed. Meeting the SLEEP requirements with a standard diesel set will necessitate tolerating either additional weight or noise. Further, these data also indicate the need for a substantial change in the requirements in order to facilitate a standard diesel SLEEP system.

Second, the Rotary diesel engine trend line shown in Figure 5-1 is a function of unknowns. The line shown could increase or decrease in slope depending upon the impact of undetermined engine characteristics. The engine will be smaller, have fewer moving parts, fewer noise generation sources, and will not suffer from reciprocating motion. These factors tend to decrease the slope magnitude. However, the engine, an internal combustion engine, generates difficult to suppress low frequency noise. This tends to increase the slope magnitude.

The third system, the Brayton engine, is the existing system closest to meeting the requirements. However, even this system fails to meet the requirements by a significant margin. This trend line does offer information on the differences in suppression capabilities of the external and internal combustion engines.

As with the Rotary, the trend curve in the Stirling system corresponds to the silencing efforts of a scaled engine. These silencing and scaling processes will likely coincide rather than occur sequentially. Again, this trend is an estimate, thus the system could fall on either side of the

requirement. However, as shown in the figure, the offers the greatest potential for meeting the SLEEP requirements in the near term.

When the Brayton, Stirling, and the Rotary Diesel are evaluated in a broader context, other difficulties arise. Although the Brayton offers an existing system able to approach the SLEEP requirements, two areas limit this system. Although developed to production stages, the Brayton system was never actually produced. This lack of production base creates problems for fielding a Brayton SLEEP generator set. Further, when fuel consumption rates and the resulting mission weight are factored into the evaluation, the large amount of fuel required erodes the weight savings of the Brayton engine.

Beyond the challenges of scaling and silencing, the Stirling faces complications, such as engine development and logistics support. The Stirling is still in a relatively immature stage of development. Further, a new technology, such as with the Stirling, impacts the existing logistics support network within the Army structure. A new technology requires significant support facilities, training, and personnel for complete incorporation into the Army network.

The Rotary Diesel engine might bridge the gap between established support systems and technological advances. Although currently a prototype engine, the existing manufacturing base and support systems should easily adapt to this technology. However, significant doubt exists as to the Rotary's ability to meet all of the SLEEP requirements.

5.5 Re-examination of the Requirements.

The risks and restraints involved in pursuing a program to meet the current SLEEP requirements suggest a brief examination of those requirements. This examination seeks to understand how the specifications may have evolved and what they mean.

Both the weight and volume SLEEP requirements seem to be based on transportation considerations. The SLEEP weight requirement matches the cross-country payload specifications of a quarter-ton, two wheeled, military design trailer [24]. The volume specification enables the generator set to be transported in Army and Air Force aircraft. Weight and/or volume exceeding the current requirement would necessitate an alternative means of transportation.

Non-dectability seems to have fostered the thermal and aural specifications. The stringent thermal requirement prevents an operational SLEEP unit from being distinguished from the surrounding environment by threat infrared imagery devices. The aural specification evolves from the SLEEP supported mission. The requirement reflects the outer perimeter which a supported unit could secure and maintain.

5.6 Schedule Requirements.

One basic assumption of this study maintained that a candidate system must meet the SLEEP requirements. The first portion of this Sensitivity Analysis has discussed the impacts of this assumption upon candidate systems. The importance of development and fielding was considered implicitly during the examination of alternatives. If development time is not critical, the Phosphoric Acid Fuel Cell receives very high marks. Although currently an adolescent technology, the lack of thermal or aural signatures make this system a most attractive alternative.

5.7 Summation of Sensitivity Analysis.

This analysis has determined that the stringent SLEEP requirements do restrict candidate technologies. If the requirements were relaxed, five technology alternatives offer potential for SLEEP. Of these five, the Phosphoric Acid Fuel Cell shows no benefit in altering the requirements based on its immaturity. Two other alternatives fail to present

economically sound options for SLEEP: the Brayton engine, and the standard diesel engine. The remaining alternatives, Stirling and Rotary Diesel, offer separate benefit potential. The Stirling engines are most likely to meet the SLEEP requirements. The Rotary Diesel may not meet all of the requirements, but offers an economically sound alternative in fielding a system.

6. ACQUISITION APPROACH

In addition to identifying the technology options potentially able to meet the SLEEP requirements and applications, this study determined the most efficient means of acquiring that technology. All Army materiel procurement uses a specified materiel acquisition cycle that may be modified to increase efficiency in terms of time and/or money. The Army Standard Acquisition Cycle is usually modified in two ways. One modification acquires commercial items that can be used to meet Army requirements. The other modification tailors the standard cycle through combining or eliminating program phases. Since generators have commercial interests and manufacturing bases outside the military, most Army generator programs use one of these modifications.

6.1 Non-Developmental Item Procurement.

Materiel procured from the commercial marketplace for introduction into the Army system, either directly or with modifications, is termed a Non-Developmental Item (NDI) procurement. A NDI procurement approach allows the Government to streamline the procurement process and reduces costs. NDI programs fall under three categories: off-the-shelf or use of a commercial product without modification; militarization of commercial subcomponents; and integrating two or more commercially available items into a single system.

Determining which technology options currently offer a NDI procurement approach, using existing hardware that meets the SLEEP requirements, required a thorough survey of commercially available generator sets and engines. As described in Section Three such a survey has been completed. The survey of commercial generators indicated that no commercial item, with or without modification, can meet the SLEEP requirement. The survey of commercial generators and the examination of noise attenuation technology indicated that adapting current commercial products will not meet the requirement.

6.2 Standard Materiel Acquisition Cycle.

The standard materiel acquisition cycle can produce the desired SLEEP capability. However, such an approach would not take advantage of the commercial interest and work in improving the capabilities of electric power generators. Technological advances and on-going research and development in miniaturization, modular components, increased reliability, and better fuel efficiency can result in enhanced SLEEP capabilities without the need for a full scale research and development effort. The current SLEEP program should capitalize on previous and on-going Government research and development efforts. Using this approach, the SLEEP program can focus on the integration of the major functional elements by using the most promising components for better efficiency and reliability, and optimal configuration to meet weight and volume specifications. Given the level of interest and capability readily available in the commercial market, the standard materiel acquisition cycle should not be pursued.

6.3 Tailored Materiel Acquisition Cycle.

A tailored materiel acquisition cycle appears best suited for acquiring a SLEEP system. Although a considerable engineering effort will be necessary to develop a program that meets Army requirements, the level of risk (technical, schedule, and cost) appears to be medium given the technological maturity of current products and components, and the availability of technical solutions, expertise, and capabilities of private industry.

The preferred materiel acquisition cycle is the Army Streamlined Acquisition Process (ASAP) Research and Development (R&D) Program. The ASAP allows the acquisition to be tailored to the unique characteristics of the SLEEP program which accelerates and simplifies the acquisition. Pursuing this acquisition approach will incorporate the advances made in industry and result in a generator set that meets the SLEEP requirements.

7. CONCLUSIONS AND RECOMMENDATIONS

An evaluation of advanced military power generation technologies has been conducted. The evaluation considered the full range of electrical power generation technologies, with special emphasis placed on diesel and multi-fuel engine driven generators which are small, lightweight, silent, and reliable. The results of this evaluation have been incorporated into the materiel acquisition documentation for the procurement of prototype hardware.

7.1 Conclusions.

Based upon this study, the following conclusions may be drawn:

Sections 1 & 2

(1) The signature suppressed, lightweight, electric energy plant is a unique program. No existing Army system can be improved to meet all of the SLEEP requirements.

(2) Maintaining the status quo will not suffice due to the threat to which the generators are exposed and the age of the currently fielded generator fleet.

Section 3

(3) Based upon the Commercial Products Status Assessment, no commercial product currently available meets the SLEEP requirements.

(4) Three technologies currently offer potential for application to the SLEEP program. They include: Rotary Diesel, Stirling, and Phosphoric Acid Fuel Cells.

(5) In conjunction with conclusions (3) and (4), meeting the SLEEP program requirements will necessitate an engine development program.

(6) Although offering potential to reduce engine noise and weight, the Rotary Diesel technology does not offer an alternative capable of meeting all of the SLEEP requirements.

(7) The Stirling technology option presents the technology alternative most likely to meet the SLEEP program goals.

(8) Both the Kinematic and Free Piston Stirling engines offer potential for the SLEEP application.

(9) The Phosphoric Acid Fuel Cell offers the optimal performance potential of the technology alternatives.

(10) In spite of conclusion (9), the current development status of Phosphoric Acid Fuel Cells inhibits a recommendation as the preferred technology alternative.

(11) Adiabatics and ceramic materials offer great potential for engine improvement. However, similar to Fuel Cells, they require more developmental effort.

(12) The Rotary Diesel technology option will require a significant acoustic enclosure developmental effort in order to meet the SLEEP signature requirements.

(13) The Stirling technology will require only a minor noise enclosure development effort due to the inherently low signature operation of this engine. As a new technology and new Army system, the Stirling will significantly impact support areas within the current Army system such as: logistics, training, MANPRINT, and RSI.

(14) Presumably, the Fuel Cell technology will require no acoustic enclosure during operation; however, the current development stage makes definite conclusions premature.

Section 4

(15) The Rotary Diesel technology offers the technical alternative with the lowest overall technical risk, as well as the lowest cost and shortest schedule.

(16) The Stirling technology option incurs a moderate level of risk in procuring a SLEEP system.

(17) The Phosphoric Acid Fuel Cell technology alternative incurs a high level of risk.

(18) The Rotary Diesel technology does offer certain trade-off advantages which may be deemed of significant value to the SLEEP effort. These include low engine weight and a relatively small impact to existing logistics, training, MANPRINT, and RSI.

(19) The Rotary Diesel technology trade-off disadvantages involve relaxing either the weight or aural signature requirement. If this is permitted, the Rotary Diesel could meet the new requirement, but the system would not be a SLEEP generator. This system would not meet the SLEEP requirements.

(20) The trade-off associated with the Stirling technology alternative exchanges a system capable of meeting the SLEEP requirements for risk and procurement schedules.

(21) The trade-off associated with the Fuel Cell technology has a very high risk level and the optimal SLEEP system performance.

(22) Based upon the Feasibility Analysis, including risks, feasibilty, and trade-offs, the Stirling technology offers the alternative with the best potential for SLEEP.

Section 5

(23) The aural and weight requirements are the most sensitive parameters to the SLEEP program. The thermal requirement also impacts SLEEP, but to a lesser degree.

(24) Due to the immaturity of the technology, Phosphoric Acid Fuel Cells have been shown to be insensitive to the requirements. That is, relaxing one or more requirements does not significantly alter this alternative's potential for SLEEP.

(25) Sensitivity to the aural and weight parameters is directly coupled; a decrease in one, increases the other. Relaxing either or both requirements would increase the potential for all alternatives to meet the requirements.

(26) Relaxing the SLEEP requirements will impact areas such as transportation, performance, support systems, etc. Significant relaxation could result in the adaptation of current industry supported engines in both the Stirling and Rotary Diesel engines.

(27) The Stirling is also sensitive to the aural and weight requirements. This alternative struggles more with the weight specification than aural.

(28) The Rotary Diesel's sensitivity includes aural, weight, and to a lesser degree thermal. This alternative faces the most significant challenges in meeting the aural requirement.

Section 6

(29) Based upon a survey of commercial generators and the examination of noise attenuation technology, a Non-Developmental Item Procurement approach is not compatible with the SLEEP requirements.

(30) Although the standard materiel acquisition cycle could produce SLEEP, given the level of interest and capability readily available in the commercial market, this cycle should not be pursued.

(31) The preferred materiel acquisition cycle for SLEEP is the ASAP R&D program.

(32) The absence of commercial and product improvement alternatives necessitates an engine development effort to meet the SLEEP requirements in the near term.

7.2 Recommendations.

Based on this study, the following primary and associated recommendations are provided:

PRIMARY RECOMMENDATIONS

(1) The Stirling engine technology should be developed for the SLEEP generator set procurement.

(2) Procurement of a SLEEP generator set should follow an ASAP procurement approach.

(3) In conjunction with recommendation (2), the attached Statement of Work for the procurement of SLEEP is recommended. (Appendix C)

(4) Similar to recommendation (3), the enclosed draft Evaluation Criteria is recommended. (Appendix C)

(5) Based on recommendation (1), the attached Conceptual Baseline Configuration is recommended. (Appendix D)

ASSOCIATED RECOMMENDATIONS

(6) Due to the potential reduction in noise, the Rotary Diesel engine developments should be closely monitored.

(7) As the optimal technology, fuel cells offer a tremendous potential benefit to SLEEP. Therefore, developments in this technology should continue to be monitored.

(8) Ceramic technology should continue to be monitored for advances in engine applications and insulator abilities because of the potential for significant reduction in generator and engine weight. It is to be noted that ceramics offer potential benefits for all SLEEP technology alternatives.

REFERENCES

[1] R.N. Belt, "Silent, Electric Power Generators For Tactical Applications, Special Study," December, 1968.

[2] P.G. Potter, J.H. Baldridge, and A. Kenyon, "Engine-Generator Set Database, Version II (GENII)," February 1987.

[3] "Stratified Charge Omnivorous Rotary Engines" product specification, John Deere & Company.

[4] "Norton Engineered For Flight" product specification.

[5] "Heavy Duty Transport Technology Development Plan," US Department of Energy, Assistant Secretary for Conservation and Renewable Energy, Office of Transportation Systems, Heat Engine Propulsion Division, DOE/CE-0130, June 1985, p.10.

[6] L. Grondalski, N. Moore, and K. Wilson, "Conceptual Design Study For Advanced Integrated Power And Environmental Control Systems For Mobile Military Applications, Phase Three Technical Report," June 1986.

[7] A.G. Daley, W.W. Marr, and T.J. Heames, "Stirling Engine Performance Optimization With Different Working Fluids," IECEC 1986, Vol. 1, p.576.

[8] Ibid. p.578.

[9] D.G. Beremand, and R.K. Shaltens, "DOE/NASA Automotive Stirling Engine Project Overview 86," IECEC 1986, Vol.1, p.432.

[10] M.J. Farmer, P.A. Lewis, J.J. Pardus, "Fuel Cell Power Plant Demonstration and Evaluation Public Service Electric & Gas Company Experience," IECEC 1986, Vol.2, p.1111.

[11] R.L. Rentz, G.L. Hagey, and R.S. Kirk, "Fuel Cells As A Long Range Highway Vehicle Propulsion Alternative," IECEC 1986, Vol.2, p.1082.

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] Ibid, p.1085.

[16] M.J. Farmer, P.A. Lewis, J.J. Pardus, "Fuel Cell Power Plant Demonstration and Evaluation Public Service Electric & Gas Company Experience," IECEC 1986, Vol.2, p.1116.

[17] F.D. Gmeindl, and V.M. Kolba, "DOE Molten Carbonate Fuel Cell Program Technology Issues And Plans," IECEC 1986, Vol.2, p.1129.

[18] "Heavy Duty Transport Technololgy Development Plan," US Department of Energy, Assistant Secretary for Conservation and Renewable Energy, Office of Transportation Systems, Heat Engine Propulsion Division, DOE/CE-0130, June 1985.

[19] P.H. Havstad, I.J. Garwin, and W.R. Wade, "A Ceramic Insert Uncooled Diesel Engine," IECEC 1986, p.3.2.

[20] L. Grondalski, N. Moore, and K. Wilson, "Conceptual Design Study For Advanced Integrated Power And Environmental Control Systems For Mobile Military Applications, Phase Three Technical Report," June 1986, p.5-39.

[21] Ibid. p.5-43.

[22] G.G. Huggins, R. Madden, and B. Murray, "Noise Control of an Underground Load-Haul-Dump Machine," July 1977, p.40.

[23] L. Grondalski, N. Moore, and K. Wilson, "Conceptual Design Study For Advanced Integrated Power And Environmental Control Systems For Mobile Military Applications, Phase Three Technical Report," June 1986.

[24] MIL-STD MS 52146, March 1981, p.2.

BIBLIOGRAPHY

Adiabatics, Inc., on-site visit, 10 November 1987.

Badgley, P., Irion, C.E., Myers, D., "Stratified Charge Rotary Aircraft Engine Technology Enablement Program, Final Report," John Deere Technologies International, Inc., 31 January 1985.

Belt, R.N., "Silent, Electric Power Generators For Tactical Applications, Special Study," DTIC AD847 696, December, 1968.

Beremand, D.G., Shaltens, R.K., "NASA/DOE Automotive Stirling Engine Project Overview 1986," IECEC '86 869099, August 25-29, 1986.

"Ceramic Automotive Stirling Engine Program," Mechanical Technology Incorporated, DOE/NASA/0311-1, August 1986.

Connelly, M., Olsson, G., "Heat Transfer To Single- and Double-Row Stirling Engine Heater Tubes," IECEC '86 869117, 1986.

Daley, J.C., Marr, W.W., Heames, T.J., "Stirling Engine Performance Optimization with Different Working Fluids," October 29, 1986.

"Eighth Annual Report to Congress on the Automotive Technology Development Program," DOE/CE-0172, December 1986.

Farmer, M.J., Lewis, P.A., Pardus, J.J., "Fuel Cell Power Plant Demonstration and Evaluation Public Service Electric & Gas Company Experience," IECEC '86, 869246, 1986.

Farrell, R.A., "Automotive Stirling Engine Program Overview," Mechanical Technology Incorporated, October 1987.

Flynn, G., MacBeth, J., "A Low Friction, Unlubricated, Uncooled Ceramic Diesel Engine - Chapter 11," SAE 8604481, 1986.

"Fuel Cell Power Plants," IECEC '86 869245, 1986.

Gmeindl, F.D., Kolba, V.M., "DOE Molten Carbonate Fuel Cell Program Technology Issues-And Plans," IECEC 1986, 869251, 1986.

Goddard, D., Whitman, W., Pumphrey, R., "Graphite/Magnesium Composites for Advanced Lightweight Rotary Engines," SAE 8605641, 1986.

Graves, R., Greene, D., Gregory,E., "Application of the Adiabatic Diesel to Heavy Trucks--A Technology Assessment," Oak Ridge National Laboratory, March 1986.

Grondalski, L., Moore, N., Wilson, K., "Conceptual Design Study For Advanced Integrated Power And Environmental Control Systems For Mobile Military Applications, Phase Three Technical Report," Jet Propulsion Laboratory, California Institute of Technology, June 1986.

Havstad, P.H., Garwin, I.J., Wade, W.R., "A Ceramic Insert Uncooled Diesel Engine," SAE 860447, 1986.

"Heavy Duty Transport Technology Development Plan," US Department of Energy, Assistant Secretary for Conservation and Renewable Energy, Office of Transportation Systems, Heat Engine Propulsion Division, DOE/CE-0130, June 1985.

Huggins, G.G., Madden, R., Murray, B., "Noise Control of an Underground Load-Haul-Dump Machine," NTIS PB-288 854, July 1977,

Industrial Acoustics Company, on site visit, 30 October 1987.

Kamo, R., Kakwani, R., "Adiabatic Engine for Improved Combustion of Powdered Coal," Adiabatics, Inc., IECEC '86 869082, 1986.

Kamo, R., Kakwani, R., Hady, W., "Adiabatic Wankel Type Rotary Engine," SAE 8606161, 1986.

Katayama, K., Watanabe, T., Matoba, K., Katoh, N., "Development of Nissan High Response Ceramic Turbocharger Rotor," SAE 8611281, 1986.

Kolin, "Recent Development of the Flat Plate Stirling Engine," University of Zagreb, IECEC '86 869113, 1986.

Krantz,A.D., "Status Of The Federal Photovoltaic Research Program," IECEC '86 869278, 1986.

Laue, H., "Mobile Electric Power Supply in the Field," Federal Republic of Germany Federal Armed Forces--Army, AD-B088 035, October 1984.

Mechanical Technology Incorporated, on site visit, 28 October 1987.

Menchen,W.R., "Development of a 0.1 kW Thermoelectric Power Generator for Military Applications," IECEC '86 8693101, 1986.

Mitsuda, A., Yamashita, Y., "Overview of Stirling Engine Development in Japan," IECEC '86 869100, 1986.

Moore, Hoehne, "Combustion Chamber Insulation Effect on the Performance of a Low Heat Rejection Cummins V 903 Engine," SAE 8603171, 1986.

Muroki, Kono, Nagao, A., "Mazda Rotary Engine Technology Combustion Characteristics," Mazda Motor Corporation, IECEC '86 869086, 1986.

Muroki, T., Miyata J., "Material Technology Development Applied to Rotary Engine at Mazda," SAE 8605601, 1986.

Nagashima, M., et.al., "Effects Of Mixing Gases On Phosphoric Acid Fuel Cell Performance," IECEC '86 869249, 1986.

Norris, R., "Combat Developer's Independent Evaluation Report for the 10 KW Gas Turbine Engine Driven Generator Set Operational Test IIA," ADB049423, July 1980.

Potter, P.G., Baldridge, J.H., Kenyon, A., "Engine-Generator Set Database, Version II (GENII)," Science Applications International Corporation, February 1987.

Rentz, R.L., Hagey, G.L., Kirk, R.S., "Fuel Cells As A Long Range Highway Vehicle Propulsion Alternative," IECEC '86 869239, 1986.

Richey, "Status and Application of Stirling Engine Technology," Mechanical Technology Incorporated, March 1987.

Santini, D.J., "Introducing Engine Innovations: An Examination of Future Markets for Brayton and Stirling Automotive Engines," Argonne National Laboratory, August 1984.

Schneider, H.W., "Evaluation of Heat Engines for Hybrid Vehicle Application," Jet Propulsion Laboratory, August 31, 1984.

Shaltens, "Advanced Stirling Conversion Systems for Terrestrial Applications," March 22-27, 1987.

Shaltens, R, "Stirling Powered Van Program Overview," DOE/NASA/50112--62-Rev., February 24-28, 1986.

Slaby, J.G., "Overview of the 1986 Free-Piston Stirling SP-100 Activities at the NASA Lewis Research Center," IECEC '86, 869098, 1986.

Tabata, W., "Automotive Stirling Engine Program - A Success," National Aeronautics and Space Administration, DOE/NASA/50112-69, August 1987.

Tanaka, Matsumura, Hirata,I., "Molten Carbonate Fuel Cell Development And System Analysis," IECEC '86 369244, 1986.

Tew, R.C. Jr., "Progress of Stirling Cycle Analysis and Loss Mechanism Characterization," October 27-30, 1986.

Thieme, L.G., "Testing of a Variable-Stroke Stirling Engine," IECEC '86 869104, 1986.

"USAF Advanced Terrestrial Energy Study Volume 1: Project Summary," Institute of Gas Technology, AFWAL-TR-82-2019, April 1983.

"USAF Mobile Power And Facility Electricity Power Systems Analysis, Volume 1 - Technical Report," AD-A142 240, March 1984.

Walker, G., Fauvel, R., "Yes, Veronica, Stirling Engines Are Good For Something," IECEC '86 869097, 1986.

Warshay, M., "Status of Commercial Fuel Cell Powerplant System Development," DOE/NASA/17088-5, August 1987.

APPENDIX A

STATEMENT OF WORK

Task Order No. 0045
Contract No. DAAK70-84-D-0053

STATEMENT OF WORK AND SERVICES

TASK ORDER TITLE: Evaluation, Analysis and Documentation Support for the 10KW Signature Suppressed Lightweight Electric Energy Plant (SLEEP)

TASK LOCATION: This task order will be accomplished primarily at the contractor's facilities and through visits to the US Army Belvoir Research, Development and Engineering Center.

CONTRACT LINE ITEMS: Sections B.1, CLINS 0004, 0005 and 0006, Sections C.2.a, b, c; and C.3 of the basic contract.

CONTRACT END ITEMS: The primary deliverable end item will be a Study Gist (B011) and a Technical Report (B007). A draft of the Final Report (B007) and the Study Gist (B011) will be delivered no later than 30 days prior to the task order completion date for Government review and approval. The Final Report and Study Gist, incorporating Government comments, will be delivered no later than eight (8) months after task order award. In-progress briefings conducted every two months will be documented by Progress/Status Meeting Reports (B001) and delivered to the Government within five days after each briefing. Cost and Performance Reports (B002) will be submitted no later than the tenth working day after the last billing date of the month. Distribution of above reports is:

a. Progress/Status Meeting Reports (B001) - one (1) copy each to STRBE-HP, STRBE-FG, and AMSTR-PVAC.

b. Cost and Performance Reports (B002) - one (1) copy each to STRBE-HP and AMSTR-PVAC.

c. Monthly Letter Progress Report (B010) - one (1) copy each to STRBE-HP, AMSTR-PBCA, and STRBE-FG.

d. Draft Technical Report (B007) - one (1) copy each to STRBE-HP and three (3) copies to STRBE-FG.

e. Technical Report (B007) and Study Gist (B011) -

- -one (1) copy to Technical Library (STRBE-BT)
- -one (1) copy to STRBE-TQ
- -two (2) copies to STRBE-HP accompanied by DD 250
- -ten (10) copies to STRBE-FG
- -two (2) copies mailed to:

Defense Technical Information Center
Cameron Station
ATTN: DTIC
Alexandria, Virginia 22314

Commander TROSCOM
ATTN: AMSTR-CS
4300 Goodfellow Boulevard
St. Louis, Missouri 63120-1798

DESCRIPTION OF WORK:

Background: The Logistics Support Directorate is responsible for the acquisition of the 10 Kilowatt Signature Suppressed Lightweight Electric Energy Plant (SLEEP). Acquisition of the best possible SLEEP capability requires use of technology and industrial capability which may approach state of the art. A technology evaluation and feasibility analysis are desired to establish a viable materiel acquisition program.

Objective: The objective of this task is to conduct an evaluation of advanced military power generation technologies, to use the resulting information to verify capability to meet materiel system requirements, and to incorporate the information into the materiel acquisition decision making process. The evaluation will consider the full range of electrical power generation technologies, with special emphasis on diesel or multi-fuel engine-driven generators that are small, lightweight, silent and reliable. Results of the evaluation will be incorporated into the materiel acquisition documentation for the procurement of prototype hardware.

Program Approach: The contractor's expertise in system/hardware integration and the materiel acquisition process will be used to conduct the technical feasibility evaluation and to prepare the procurement package. The project will be accomplished as described below:

a. Conduct an evaluation of advanced military power generation technologies and capabilities that are applicable to SLEEP.

b. Determine feasible technical characteristics for SLEEP considering available technologies and products, user requirements, and other considerations, and conduct trade-off analyses where appropriate.

c. Prepare applicable procurement documentation based on the technology evaluation and feasibility analysis described above.

Task I: Conduct an Evaluation of Advanced Military Power Generation Capabilities Applicable to SLEEP. The contractor will conduct an assessment of the technologies and systems that are applicable to a SLEEP capability. This will be accomplished by maximum use of in-house Government documents

and a survey of state of the art power generation literature. The evaluation will be broad but will emphasize the following specialized areas of military power generation: engine-driven technology employing diesel or multi-fuel systems; small, lightweight, compact and easily transportable power packages; low aural and thermal signature and/or signature suppression systems; high reliability and ease of logistical support; system safety and ease of operation; and capability to transfer/modify the technology to alternative military applications. The final result of this task will be a succinct description of the state of the art for the desired specialized areas of technology, an evaluation of industry capability in the desired areas, and a general evaluation of the risks alloctated with use of the specialized technologies in a system such as SLEEP. (C.2a)

<u>Task II: Determine Feasible Technical Characteristics for SLEEP</u>. Based on the state of the art survey and analysis conducted in Task 1, the contractor will review current SLEEP requirements in light of currently available technology. Where disconnects exist, they will be called to the attention of the Government technical representative. The contractor will help develop trade-off selections (quantitative where possible) to help establish feasible requirements and specifications as they relate to the current Required Operational Capabilities (ROC) document for SLEEP. The analysis will consider trade-offs in the specialized technical areas described above, as well as trade-offs in terms of risk, and will consider the impact of SLEEP on the standard military systems (logistics, training, manpower and personnel integration (MANPRINT), Rationalization/Standardization and Reliability (RSI), cost and others). In conjunction with Government representatives, the contractor will establish relative priorities, criteria and weights on the elements of trade-off analyses for the various technologies and system elements. The determination of feasible characteristics will include the requirement to integrate all elements of SLEEP into an integral power generation system. The final result of the analysis will be a description of trade-offs which appear feasible for achieving the SLEEP ROC, a Conceptual Baseline Configuration based on the preferred set of technical and operational parameters, and a draft version of the Technical Requirements portion of the procurement Request for Proposal (RFP). Government input to these products will oe achieved through briefings and technical discussions. (C.2c)

<u>Task III: Prepare Applicable Procurement Documentation</u>. Based on the analysis and recommendations developed in Tasks I and II, and in conjunction with Government technical representatives, the contractor will develop selected documentation for inclusion into the procurement package. The documentation effort will include reviewing the current Operational and Organizational (O&O) Plan and Required Operational Capability (ROC), updating the Acquisition Strategy (AS), preparing the Concept Formulation Package (CFP), System Concept Paper (SCP), and Test and Evaluation Master Plan (TEMP), and drafting preliminary version of the Acquisition Plan (AP). In addition the contractor will assist in the development of the Environmental Assessment (EA), Configuration Management Plan (CMP), Baseline Cost Estimate (BCE), and draft Purchase Description. (C.2b)

TASK IV: All documentation required in Task III shall address Human Engineering requirements in accordance with MIL-H-46855 and MIL-STDS-1472, and 1474. (C.1d)

Task V: Technical Report and Study Gist. The contractor will document the results of the above tasks in a final Technical Report and Study Gist. (C.3)

CLASSIFICATION: Work on this task order may be classified up to and including SECRET. If classified information is included in the final report, it will be placed in a separate annex.

PERFORMANCE PERIOD: From date of award through 14 January 1988.

POINTS OF CONTACT: Mr. Anthony Rabalais, (703) 664-5171, is the COR and Mr. Howard Clark, (703) 664-2668, is the technical point of contact.

APPENDIX B

DATA SUPPORTING ALTERNATIVE ANALYSIS

This appendix contains the supporting data for the analyses conducted in Section 4. The data is organized into four sections. Five graphs contain data for the first section, the Quantitative System Parameters data. Three tables record the grades of the Alternative Evaluation Criteria in the second section. The third section contains the scoring data in tabular form. The final section presents a table of the Technology Ratings and the Technology Totals.

Section B-1 Quantitative System Parameter Data

Quantitative system parameters include the following: Aural Signature, Reliability, Weight, Thermal Signature, and Volume. These five system parameters were chosen as the quantitative factors for two reasons. These parameters represent the most important factors to a successful SLEEP development program, and, with the possible exception of aural and thermal signatures, these factors represent specifications standard to most manufactured products.

Data for the quantitative system parameters are presented in Figures B-1 to B-5. The evaluation criteria are necessarily technology independent. The SLEEP requirement arbitrarily received a grade of 0.8. The maximum grade attainable for exceeding the requirements was 1.0. Changes in the slope of a line indicate a change in the grade. For example, in Figure B-1, improving the aural detection distance above the required 100 meters is very useful to the user and thus very little change in slope occurs in the line. The user benefits little from a thermal signature exceeding the requirement. The greater slope change in the line of Figure B-3 reflects this situation.

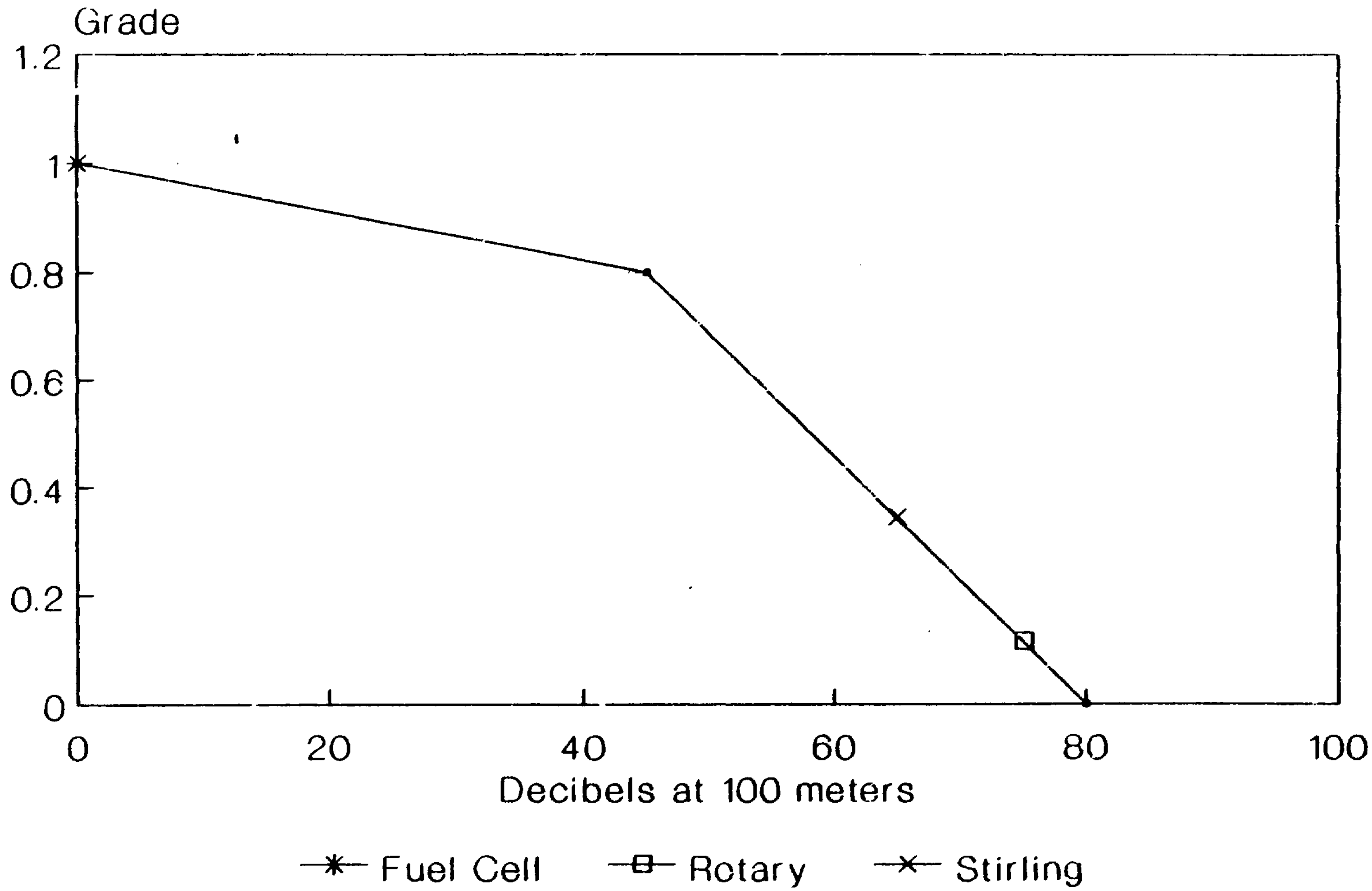

FIGURE B-1. AURAL SIGNATURE GRADING

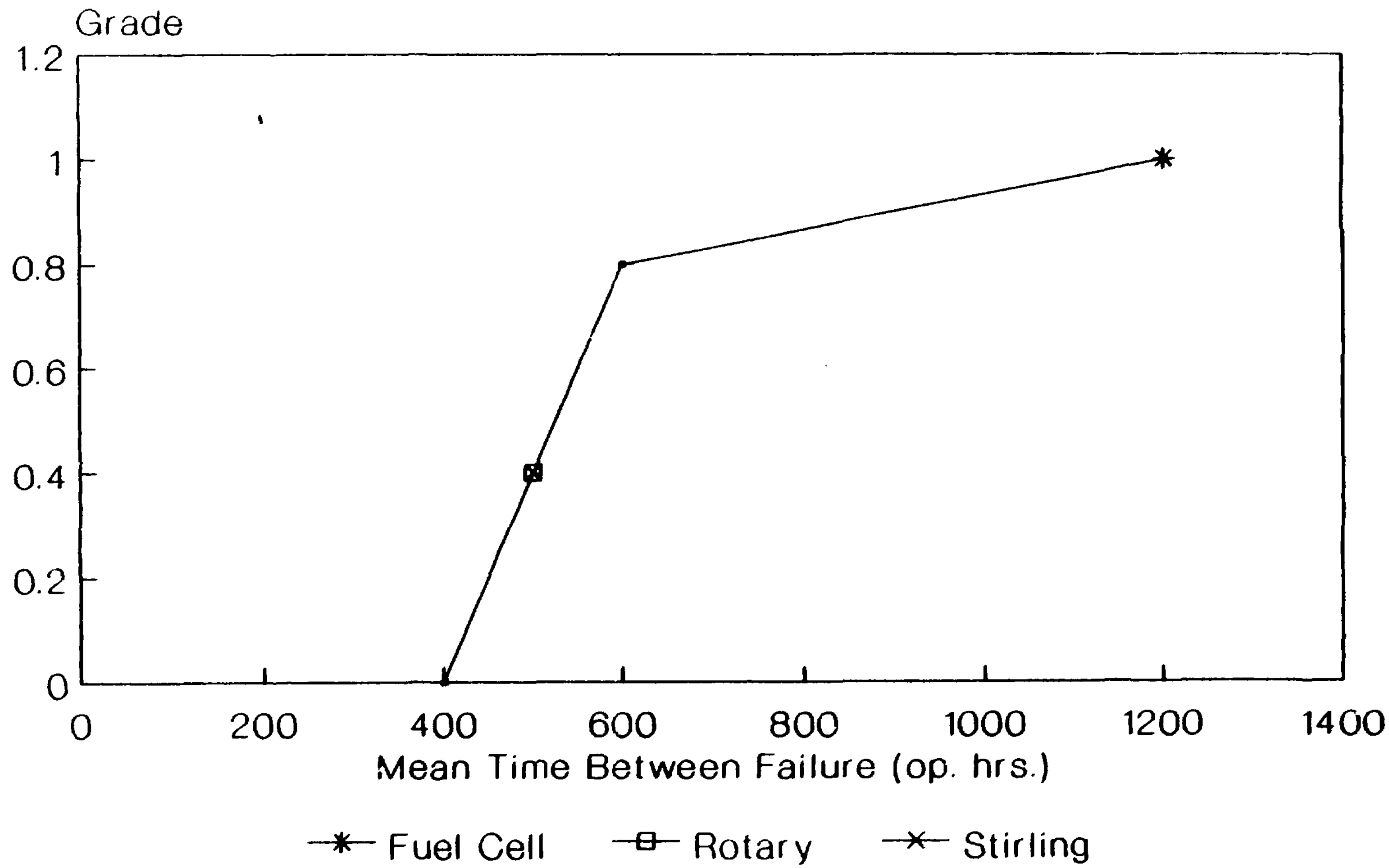

FIGURE B-2. SYSTEM RELIABILITY GRADING

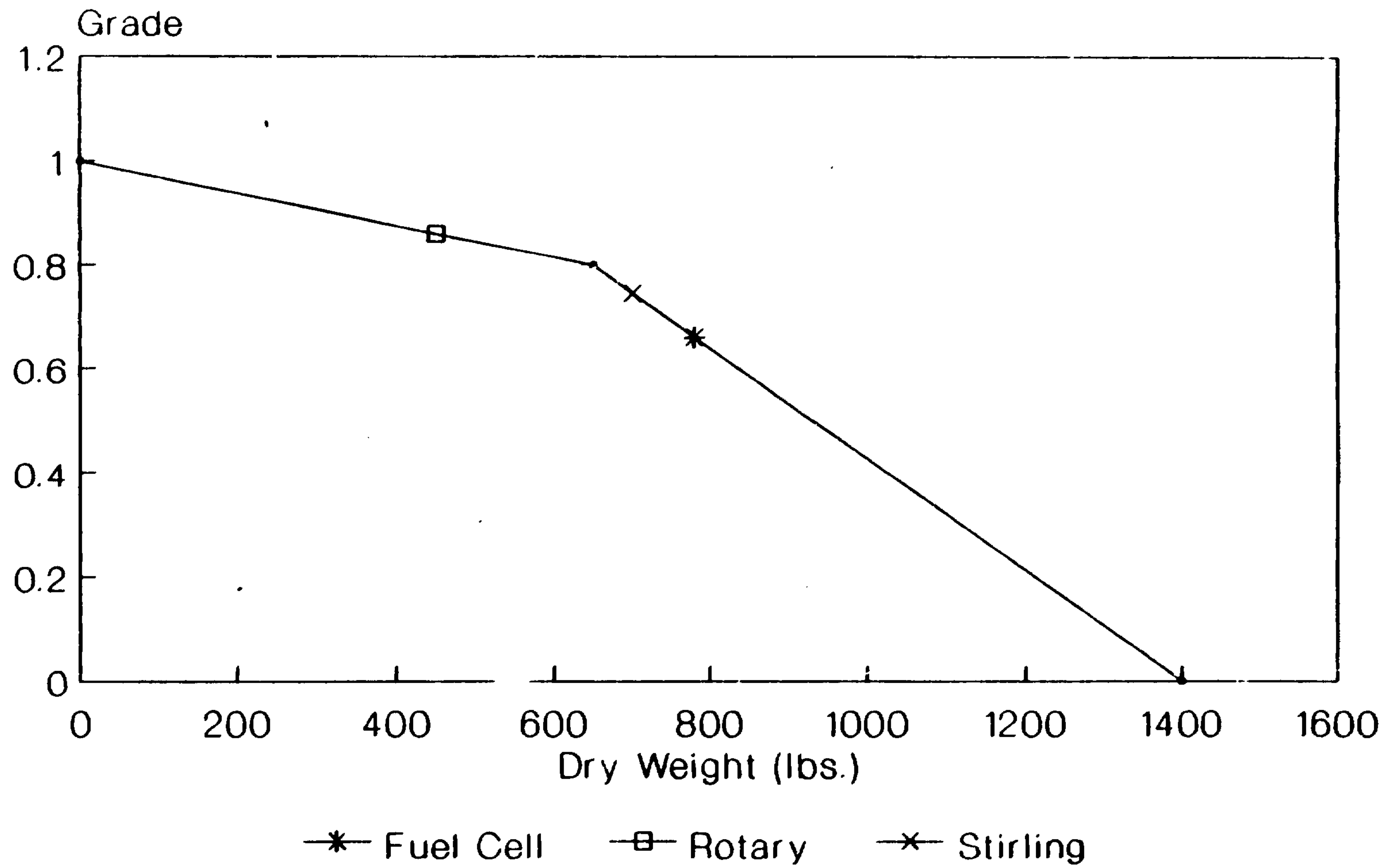

FIGURE B-3. SYSTEM WEIGHT GRADING

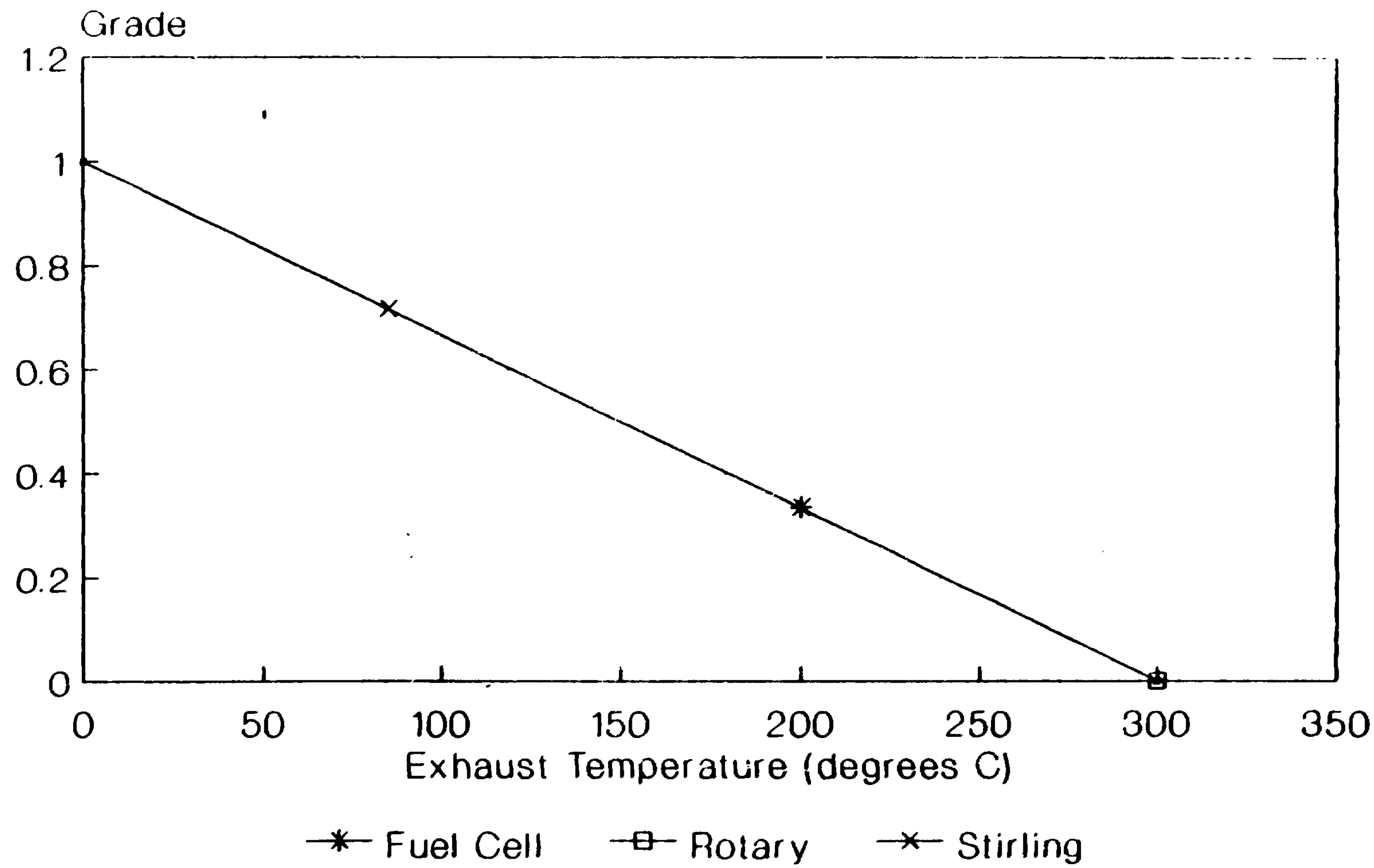

FIGURE B-4. THERMAL SIGNATURE GRADING

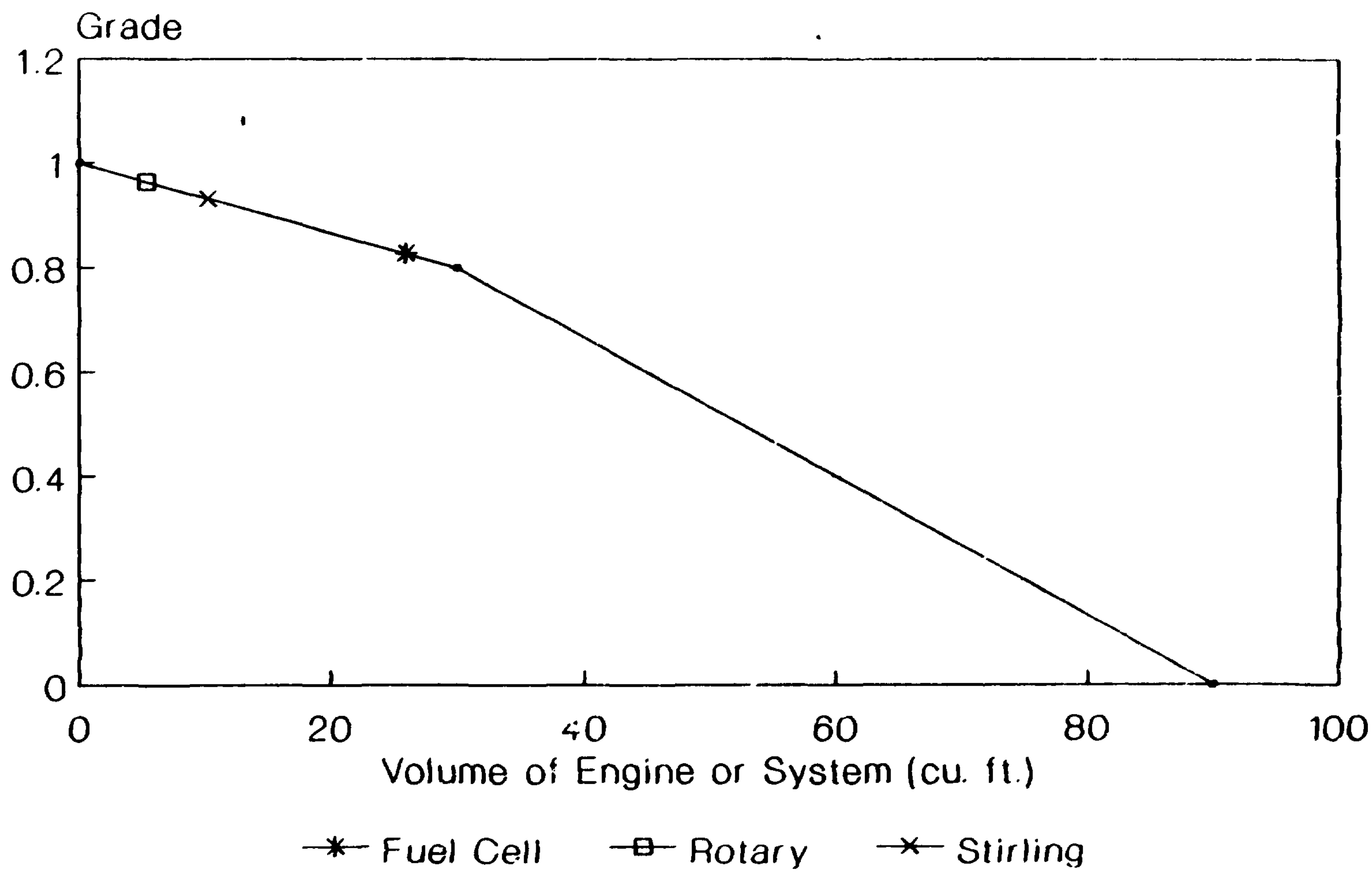

FIGURE B-5. SYSTEM VOLUME GRADING

Section B-2 Alternative Evaluation Criteria Grading

As stated in Section 4, the technology alternative comparison involves four processes. The result yields a total quantitative value comparing the alternatives.

The first process evaluates a particular system parameter or technology standard based on the system performance and assigns a grade. The grade is a numerical value based on a scale between 0.0 and 0.9; the higher the system performance, the higher the grade.

In the second process, a parameter or standard score develops as the product of the parameter/standard grade and the previously assigned weighting factor, i.e. the grade multiplied by the weight. A vertical summation of the individual parameter/standard scores determines the alternative rating in the third process. Since there are three comparison categories, two system parameters and the technology standard, three alternative rating values will be determined for each technology option. The final comparison process combines the three alternative ratings to produce a technology total for each technology alternative.

Tables B-1 to B-3 contain the weighting factors assigned to the system parameters and technology standards. These tables are identical to those found in Section 4. Tables B-4 to B-6 contain the grading data for the quantitative system parameters, the qualitative system parameters, and the technology standards respectively.

TABLE B-1. WEIGHTING OF QUANTITATIVE FACTORS.

Aural Signature	5
Reliability	5
Weight	5
Thermal Signature	4
Volume	3

TABLE B-2. WEIGHTING OF QUALITATIVE FACTORS.

Electrical Performance	4
Power Quality	4
Fuel Requirements	3
Maintainability	3
Fuel Efficiency	2
High Altitude Operation	2
Low Temperature Operation	2
System Life	1

TABLE B-3. WEIGHTING OF TECHNOLOGY STANDARDS.

Technology Maturity	5
Operation and Maintenance Costs	4
Acquisition Costs	3
System Complexity	3

TABLE B-4. GRADING FOR QUANTITATIVE FACTORS.

PARAMETER	DIESEL	STIRLING	FUEL CELL
AURAL SIGNATURE	0.27	1.0	1.0
RELIABILITY	0.82	0.4	1.0
WEIGHT	0.11	0.75	0.65
THERMAL SIGNATURE	0	1.0	1.0
VOLUME	0.63	0.93	0.83

TABLE B-5. GRADES FOR QUALITATIVE FACTORS

PARAMETER	DIESEL	STIRLING	FUEL CELL
ELECTRICAL PERFORMANCE	0.8	0.8	0.6
POWER QUALITY	0.8	0.8	0.9
FUEL REQUIREMENTS	0.8	0.9	0.7
MAINTAINABILITY	0.8	0.5	0.2
FUEL EFFICIENCY	0.8	0.9	0.9
HIGH ALTITUDE OPERATION	0.8	0.9	0.9
LOW TEMPERATURE OPERATION	0.8	0.8	0.6
SYSTEM LIFE	0.8	0.9	0.6

TABLE B-6. GRADING FOR TECHNOLOGY STANDARDS

STANDARD	DIESEL	STIRLING	FUEL CELL
MATURITY OF TECHNOLOGY	0.9	0.6	0.2
OPERATION & MAINTENANCE COST	0.8	0.6	0.4
ACQUISITION COST	0.8	0.7	0.3
SYSTEM COMPLEXITY	0.6	0.6	0.7

Section B-3 Alternative Evaluation Criteria Scoring

This section contains data for the alternative evaluation criteria scoring. The data are compiled according to the quantitative system parameters in Table B-7, the qualitative system parameters in Table B-8, and the technology standards in Table B-9.

TABLE B-7. SCORES FOR QUANTITATIVE PARAMETERS.

PARAMETER	DIESEL	STIRLING	FUEL CELL
AURAL SIGNATURE	1.4	5	5
RELIABILITY	4.1	2	5
WEIGHT	0.6	3.8	3.2
THERMAL SIGNATURE	0	4	4
VOLUME	1.9	2.8	2.5
TOTALS	8	17.6	19.7

TABLE B-8. SCORES FOR QUALITATIVE PARAMETERS

PARAMETER	DIESEL	STIRLING	FUEL CELL
ELECTRICAL PERFORMANCE	3.2	3.2	2.4
POWER QUALITY	3.2	3.2	3.6
FUEL REQUIREMENT	2.4	2.7	2.1
MAINTAINABILITY	2.4	1.5	0.6
FUEL EFFICIENCY	1.6	1.8	1.8
HIGH ALTITUDE OPERATION	1.6	1.8	1.8
LOW TEMPERATURE OPERATION	1.6	1.6	1.2
SYSTEM LIFE	0.8	0.8	0.6
TOTALS	16.8	16.7	14.1

TABLE B-9. SCORES FOR TECHNOLOGY STANDARDS.

STANDARD	FEASIBLE ALTERNATIVES		
	DIESEL	STIRLING	FUEL CELL
TECHNOLOGY MATURITY	4.5	3	1
OPERATION & MAINTENANCE COST	3.2	2.4	1.6
ACQUISITION COST	2.4	2.1	0.9
SYSTEM COMPLEXITY	1.8	1.8	2.1
TOTALS	11.9	9.3	5.6

Section B-4 Alternative Evaluation Criteria Ratings

This section contains the data for the Alternative Evaluation Criteria Ratings and the Technology Totals. The data are shown below in Table B-10.

TABLE B-10. RATINGS OF TECHNOLOGIES BY CATEGORY

CATEGORY	DIESEL	STIRLING	FUEL CELL
QUANTITATIVE PARAMETER	8.0	17.6	19.7
QUALITATIVE PARAMETER	17.6	17.6	14.7
TECHNOLOGY STANDARD	11.9	9.3	5.6
TECHNOLOGY TOTALS	37.5	44.5	40.0

APPENDIX C

STATEMENT OF WORK AND EVALUATION CRITERIA

This Appendix contains samples of technical requirements and evaluation criteria for incorporation into a Request for Proposal or Request for Quotation. Section C - Specification/Description and Section M - Evaluation Factors for Award are included.

SECTION C

DESCRIPTION/SPECIFICATION

C.1 Work and Services The work and services to be performed hereunder shall be subject to the requirements and standards contained in the following documents which are attached hereto and made a part hereof:

a. Attachment 1, Purchase Description, Generator Sets, Signature Suppressed Lightweight Electric Energy Plant; 10kW; 60Hz, 400Hz, and DC (Tactical) dated 20 November 1987.

b. Attachment 2, Contract Data Requirements List, DD Form 1423.

c. Attachment 3, Contract Security Classification Specification, DD Form 254.

C.2 Ordering Data Ordering data for Alternative A required in accordance with paragraph 6.2 of Purchase Description, Attachment 1, is as follows:

a. Purchase Description, Generator Sets, Signature Suppressed Lightweight Electric Energy Plant; 10kW; 60Hz, 400Hz, and DC (Tactical), dated 20 November 1987.

b. Three (3) 10kW-60Hz and three (3) 10kW-60Hz, and three (3) 10kW-DC prototype sets nine (9) sets total, shall be furnished.

c. Not applicable.

d. Ground rods shall be furnished.

e. Not applicable

f. Paralleling cables shall be furnished with each prototype, nine (9) total.

g. A remote start-stop box shall be furnished for one (1) prototype set of each size, two (2) total.

h. One (1) electric or one (1) fuel burning winterization kit shall be furnished for one (1) prototype set of each size [two (2) kits for each size].

i. Not applicable.

j. Not applicable.

k. Sets shall be preserved, packaged and packed Level Commercial.

C.3 Production Performance Limits The performance limits of Attachment 1 may apply to production sets and the range of performance limits necessary to assure production tolerance shall be provided for in prototype sets.

C.4 Training and Training Equipment Plan

NOTE: The numbers in parentheses reference paragraph numbers in Data Item Description (DID) DI-H-7066.

1. General Requirements

The contractor shall develop and conduct a training program for the 10kW Signature Suppressed Lightweight Electric Energy Plant (10kW SLEEP) Generator Sets. The purpose of the training is to train test personnel.

A Training Conference Review (TCR) shall be convened by the contractor at his facility with in thirty (30) days after contract award. The TCR shall identify and resolve training problems that might arise, review training software deliverable in accordance with the data items set forth in Contract Data Requirements List (CDRL), DD Form 1423, and also to discuss other training areas of mutual interest to the contractor and Government. A training milestone schedule establishing reviews, deliverables and training course dates will be established and mutually agreed upon by Contractor and Government. All dates established on the training milestone schedule are subject to change based on the hardware delivery date. Subsequent TCR's still be convened as required.

2. Contract Requirements

The contractor agrees to provide tools, test equipment, training documentation, necessary training aids, technical publication(s), special facilities as required and instructions for Government personnel on operation, organizational maintenance and repair of system/items identified under this contract. The fulfillment if requirements shall be subject to the following conditions: (10.3)

a. Conduct one course of technical maintenance training for a maximum of 20 trainees. (10.3.2.4) The training course shall cover operational and organizational maintenance training. Maintenance technical training shall include, but not be limited to, System Familiarization, Critical Maintenance Tasks, Trouble-Shooting and recurring tasks necessary to operate and maintain the 10kW SLEEP Generator Sets.

b. Course length, content and execution of training shall be based on contractor prepared and Government approved Program of Instruction (PCI). (ELIN AOON & AOOP).

c. In addition to trainees, the Government reserves the right to designate no more than two monitors for each training course procured. Such monitor(s) will be responsible for coordinating class activities to meet the

contractor's Program of Instruction (POI) and evaluate execution of training course. (10.3.2.6)

d. Class will be conducted on a five (5) day, eight-hour basis, Monday through Friday. (10.3.2.7)

e. Training milestone dates will be established as mutually agreed upon by the contractor and the Government. Such agreement shall be based on the completion of the training documentation, availability of equipment and the time frame established in the milestone schedule during the TCR. (10.3.2.7)

f. As designated in the milestone schedule during the TCR, the contractor shall forward a training schedule to Commander, U.S. Army Belvoir Research, Development, and Engineering Center, ATTN: Howard Clark, Fort Belvoir, Virginia 22060, for review and approval. The Government shall review the training schedule and furnish approval/comments with a preliminary roster of trainees NLT sixty (60) days after receipt of the training schedule. (10.3.2.7)

g. Subject classes shall be conducted at contractor's facilities or at Government facilities, at the option of the Government. If the Government decides that the training classes will be conducted at the contractor's facilities, then the contractor shall be responsible for providing adequate classroom and laboratory space, instructors, workbooks, instructional guides, practical exercises, examinations, consumable materials, and written and visual media necessary for the proper conduct of the training courses, at no additional cost to the Government. (10.3.2.8)

h. The contractor can provide and utilize his existing training aid/equipment as deemed necessary to enhance the training program. The training aids and materials specifically developed are manufactured under this contract for conduct of this training program will become Government property.

i. In addition to POI content, the contractor is permitted to augment his presentation if such will be beneficial to student's understanding of subject matter and the Government agrees to such augmentation during review of course documentation, however, all augmentations shall be noted in the "Instructional Tactics Column" of the individual lesson plan. Samples of such augmentations are as follows:

(1) Display of damaged and/or unserviceable parts or assemblies, which will aid the students in establishing the power operating and maintenance procedures for the system or item being taught.

(2) Display of artificial problems (bugging) so that the necessary behavior will establish the appropriate fault recognition, isolation, and correction. (10.3.2.13)

j. The contractor shall provide to each trainee a training package containing copies of the training material used in the course, i.e., Program of Instruction, Lesson Plan (LP), schematics, graphic training aids, one copy of appropriate maintenance manual(s) and maintenance allocation chart. Training materials, maintenance allocated charts and maintenance manual(s) shall be the same as procured under their respective clauses in the contract. The trainee will retain possession of all items provided by the contractor. (10.4)

k. Transportation and other personnel service expenses for Government personnel will be paid for by those personnel and/or the Government and are not reimbursable costs to the contractor (10.6.1.1)

l. The New Equipment Training Course hereunder shall be as ordered for the Government by the Contracting Officer. Invoices for payments for the instructions and services furnished hereunder shall be as indicated in each order. The invoices shall be accompanied by a concise statement describing the training instructors and services rendered, the encompassing period(s) and the name(s) of the instructor(s) for the applicable period(s). (10.6)

m. All Government Furnished Equipment (GFE) requirements will be reviewed and approved on an individual basis by the Government

n. The Government will furnish Certificate of Training Form DA 87 and DD Form 1556, to the contractor for issuance to the students upon completion of the course. (To be completed by the contractor).

C.5 Technical Support

The contractor shall provide all necessary technical support consisting of the following throughout the period of Government Testing. The contractor shall provide troubleshooting and repair services (including material and spare parts) necessary to maintain the SLEEP generator sets in operational condition. Technical support shall be provided within two (2) days after each notification by the Contracting Officer. These services shall be performed at a Government facility or test site, within the continental United States, except when the nature of repairs requires return of an inoperable set to the Contractor's facility (as determined by the Contracting Officer Representative). Technical support shall also include furnishing of failure analyses and proposed corrective actions (where applicable) for all failures during Government testing. On-site technical support shall normally be required when necessary to restore the sets to operation by other than troubleshooting in accordance with the commercial manuals furnished and by replacement of failed parts with identical parts. Modifications to or refurbishment of prototype sets shall be accomplished by contractor personnel. These modifications are to include installation of thermocouples (Copper-Constantan or Chromel-Alumel for appropriate temperature ranges) and provisions for NPT fittings at appropriate locations to permit the thermal and pressure measurements required by Method 695.1 of MIL-STD-705.

C.6 Requirements for Deterioration Prevention Program

1. The contractor shall establish a deterioration prevention program as an integral discipline during the design and fabrication of the SLEEP generator sets. The program shall include a framework for selection of materials, treatments and fabrication techniques for deterioration prevention, and a program to establish efficacy of deterioration prevention.

The coordinator for deterioration prevention and control in the contractor's organization responsible for management of the Deterioration Prevention Program will be identified. Authority and responsibility of the coordinator shall be delineated in the Deterioration Prevention Program Plan (ELIN AOOH).

2. General Surveillance. The Contractor shall:

a. Conduct a thorough and continuous examination of all system, materials, components and treatments to ensure that the use of plating, painting, chemical coating, metal treating, fungus control, etc., is consistent with the requirements of the Purchase Description. Particular attention shall be given to avoiding construction that promotes corrosion through the admission and retention of water, either directly or by condensation.

b. Be cognizant of the possibilities of deterioration caused by incompatibility of metals and materials.

c. Monitor and inspect the deterioration prevention measures instituted by all subcontractors, to ensure their compliance to the requirements the Purchase Description.

d. Permit direct contacts of the procuring agencies designees with all subcontractors specifically regarding deterioration of materials and prevention measures, requiring complete cooperation of the subcontractors with the procuring agency.

SECTION M

EVALUATION AND AWARD FACTORS

M.1 Basis for Award

A. The Basis for Award of any contract resulting from this solicitation shall be an integrated assessment of criteria designed to determine which proposals offer the best prospect for accomplishing the Government's requirements. The source selection decision will take into account the contractor's capability to interpret, perform, and satisfactorily complete the manufacturing, engineering, and technical data preparation requirements of the proposed contract at the most advantageous price to the Government. Technical capability is of such importance that the Government reserves the right to award to other than the lowest offeror. Technical consideration will weigh approximately 3 times as much as cost consideration. Management consideration will weigh approximately 2 times as much as cost consideration. Government rights to data will be evaluated in both the technical and cost areas. There are three (3) prime factors which will be considered in evaluating for award:

1. Technical approach

2. Management approach

3. Cost-consideration

4. The Proposal shall contain sufficient information to clearly demonstrate the engineering merit of the proposed design, compliance with the requirements, the adequacy of plans for fabrication and test, the methods of contract management, and the quality assurance plans.

C. proposers are advised to take their initial proposals clear and complete so that additional information and explanation are not needed since the Government may make a final determination as to acceptability solely on the basis of the proposal as submitted. The Technical Proposal <u>shall</u> clearly indicate how <u>each</u> item in the Purchase Description is to be accomplished, and <u>shall</u> include drawings, specifications and narrative descriptions sufficient to delineate the proposer's design. In no case shall words, "We will comply with the requirements of paragraph ______" or equivalent wording be acceptable to meet requirements of this proposal.

D. A Technical Proposal from each bidder shall use the title and number:

"Technical Proposal XXXXXX TP
10kW SLEEP Generator Set"

Each Technical Proposal shall cover the three different mode sets (60Hz, 400Hz and DC) and be divided for evaluation purposes, in descending order of importance, as follows:

1. ENGINE/GENERATOR DESIGN - This section shall include complete descriptions the engine. The description shall include drawings, specifications and components used as well as any other data the contractor would like to supply to include information regarding the multifuel capabilities of the engine. This section shall include a complete description of the generator. The description shall include analysis, design descriptions and specifications.

2. STRUCTURE AND PACKAGING - A plan for structural arrangement and enclosure shall be described. The size and weight shall be provided, with size and weight breakdown of all major components.

3. RELIABILITY, AVAILABILITY, AND MAINTAINABILITY - This section will contain the contractors approach to meeting the reliability, availability, and maintainability goals. The methods for performing and reporting

reliability and maintainability allocations and predictions. Procedures for assuring the reliability of parts, components, and assemblies and the methods for assuring reliability growth will be explained. The approach to development of predictions for logistics element requirements to include the development of preventive maintenance tasks and programs. Explanations of reliability and maintainability test methods and procedures are also required. In addition, previous experience in the reliability and maintainability programs for similar electro-mechanical equipment.

4. AURAL AND INFRARED SIGNATURES - An analysis of aural and thermal IR suppression requirements for the proposed generators set will be provided. The technique proposed to reduce signatures to levels consistent with the requirements shall be given with predictions and facts to substantiate those predictions. The proposals shall include a detailed description of the approach for materials selection, mechanical design, and systems integration to develop a set which shall provide the signature suppression specified.

5. NUCLEAR, BIOLOGICAL, AND CHEMICAL SURVIVABILITY - This section shall include a detailed description of the approach for materials selection, mechanical design, circuit design, and systems integration to develop a set which shall survive the specified nuclear environment. The proposal shall include a listing of the design guidelines to ensure the specified nuclear survivability, a detailed description of the approach proposed for verification of this survivability at the various stages of the design, and the proposed uses of simulation facilities for tests. Describe design approach to achieve biological and chemical survivability.

6. QUALITY ASSURANCES, HUMAN ENGINEERING, DETERIORATION PREVENTION, AND SOFTWARE (DATA ITEMS) - Approach to meeting the quality assurance requirements shall be discussed. Human Engineering considerations shall be discussed. Approach to meeting the Deterioration Prevention Program requirements shall be addressed. Software (data items) approach shall be addressed.

7. SUBSYSTEMS AND CONTROLS - This section includes a description of each device, such as, meters, gauges, lights, switches, etc., to be used. Engine and generator controls shall also be described. A complete description of the following subsystems is also required:

a. Cold Starting Aids

b. Electrical Cranking/Battery Charging System

c. Governing/Paralleling System

d. Wiring and Cable

e. Fuel System

f. Lubricating System

g. Engine/Generator Cooling System

h. Protection System

i. Optional Kits and Equipment

8. STANDARDIZATION - The proposer shall describe plans to achieve standardization with other generator sets. The interchangeable parts shall be described.

F. A Management Proposal from each bidder shall contain the following separate documents with each proposal using the title and number specified below:

Management Proposal - XXXXXX MP
10kW SLEEP Generator Set

Each Management Proposal shall be divided into three sections for evaluation purposes. The first section shall include the requirements of 1, 2, 3, and 4. The second section shall include the requirements of 5, 6 and 7, and the third section the requirements of item 8. Section 2 will be utilized to evaluate capability to perform and meet the requirements of this solicitation. Section 2 is most important. Section 1 is less important. Section 3 is of least importance.

1. PROPOSER'S OVERALL SCHEDULE - The proposer shall set forth in diagram format the time-phased schedule which will show the sequence of starting and the estimated duration of all tasks and subtasks of the program. The level of breakdown and the degree of detail is left to the discretion of the proposer, but should be sufficiently detailed to demonstrate the proposer's grasp of:

a. The total program.

b. How the tasks and sub-tasks are inter-related.

c. The lead times anticipated for delivery of all sub-contract items.

d. Types and amount of tests to be conducted. A test matrix is recommended.

Tasks shall be plotted against a baseline of calendar days with an origin of "contract award date." The key events shall be appropriately labeled on the baseline.

2. PROPOSER'S CONTRACT MANAGEMENT - The proposer is to provide an organization chart showing the relationship that this program will have, to overall management, engineering, logistics support, quality control, purchasing, manufacturing, contract administration, etc.

3. PROPOSER'S PERSONNEL - A list of supervisory personnel who will be directly involved in the contract, the number and type of employees that will be under their supervision, and the project engineer(s) who will be responsible. Included must be resumes showing education and experience (including specialized experience with engine generator sets) of personnel who will be utilized on the program, including both managerial and technical personnel. Resumes shall indicate whether the person is a current employee and is normally resident at the plant in which this project is to be accomplished. The proposer shall indicate the percentage of time that each of the personnel will be utilized on this program.

4. CONFIGURATION MANAGEMENT - A description of how the configuration is established and how engineering changes to the configuration are controlled, identified, tracked, and recorded during design, fabrication and test of the prototype units shall be submitted.

5. PROPOSER'S RESEARCH AND DEVELOPMENT EXPERIENCE - Include a list of all research and development projects involving power generation technology performed during the past ten (10) years. Provide lists of three separate of research and development that indicate the source of funding. These categories are: independent, commercial, and Government. If research and development has not been performed in a given category, so state.

6. PROPOSER'S SYSTEMS ENGINEERING EXPERIENCE - Include a list of all contracts involving the development power generation technology in which the proposer performed systems engineering tasks. Systems engineering includes integrated logistics support, system safety, reliability, maintainability, human factors, life-cycle cost, concept development, system synthesis, and trade-off analysis.

7. PROPOSER'S COMMERCIAL EXPERIENCE - Include a list of commercial generator sets, of generally the same size and configuration, developed and/or fabricated during the past ten (10) years. State when, where, and by whom the sets were used. Specifications, photographs, technical descriptions, and other data will be required and must be submitted to

support the proposal.

8. PROPOSER'S GOVERNMENT CONTRACTS - Include a list of all Government contracts for generator sets of generally the same size and configuration awarded to the proper during the past ten (10) years. The information shall include a general description of the units, the date of award, the contracting office, the number of units involved, the original contract schedule, actual or current delivery schedule and reasons for any difference. List all Government contracts within the past ten years which were terminated prior to completion along with the reason for termination.

7. PROPOSER'S PRODUCTION CAPACITY - Include total dollar volume of business for the past five years and the percentage that was Government. Address capability to deliver production hardware and software to an accelerated delivery schedule.

8. DESCRIPTION OF PHYSICAL PLANT - A description of the available plant, equipment, test facilities, and instrumentation owned or controlled by the proposer which will be used on the project during any phase of the program. A description of additional plant(s), equipment, test facilities, and instrumentation including their location, that will be sub-contracted or leased to support the program shall be supplied. The information must include a statement as to when additional plant facilities will be available referenced to date of award.

G. A Cost Proposal from each bidder shall contain the following separate exhibits with each proposal using the title and number specified below.

1. Cost Propesal - XXXXXX CP
   10kW SLEEP Generator Set

Evaluation of the cost proposal will be based on cost realism. The Government may consider the cost of acquiring data rights for <u>not only</u> cost realism, <u>but also</u> total cost impact on the SLEEP generator set program.

APPENDIX D

CONCEPTUAL DESIGN DESCRIPTION

CONCEPTUAL DESIGN DESCRIPTION

A SLEEP generator set using Stirling technology will meet the SLEEP requirements. Inherent qualities of this engine include signature suppression and quiet, efficient operation. As an external combustion engine, the Stirling engine circumvents the low frequency noise generation associated with internal combustion engines. The SLEEP generator set will replace existing sets of similar power rating in form, fit, and function.

Advantages of the Stirling Engine include: low aural and thermal signatures, high efficiency, lower required maintenance, and multifuel capability. For continuous operation, as in the SLEEP application, performance levels exhibiting very high efficiencies are expected. Additionally, the Stirling engine efficiency is essentially load independent. Therefore, optimal fuel consumption and thermal signatures will not vary significantly with varying load levels.

A further inherent advantage of the Stirling engine revolves around the required maintenance level. Attributes such as: one ignitor, no catalytic converter, no particulate traps required for diesel operation, no oil or oil filter changes required, and minimal lubrication requirements provide the potential for lower maintenance costs, high reliability, and long life. The Stirling Engine also offers an additional advantage in multifuel capability. The engine operates on diesel, gasoline, JP 4, 5, & 8 fuels, and changing fuels requires no modifications.

The Stirling engine produces power in true sinusoidal form. The arrangement of the power strokes was designed for sinusoidal form for ease in analysis during development. As a result, the Stirling engine offers smooth power generation which increases power quality and decreases noise generation.

The engine has no strategic materials nor does it rely on ceramic technology. The vast majority (estimated 95%) of the manufacturing

processes associated with the Stirling engine are standard to prevailing manufacturing technology.

The Stirling development engine uses hydrogen as the working fluid. Helium, an inert gas, would replace hydrogen as the working fluid in military applications. This eliminates the need to store and transport hydrogen for the required semi-annual working gas replenishment. The Stirling SLEEP engine life would increase because a stationary engine, such as SLEEP (in operation) runs at lower pressure levels than a mobile system such as an automobile. Using helium as the working fluid at reduced pressure levels could increase set life up to 20,000 hours. The use of helium in the engine would not significantly penalize engine performance levels to require an engine redesign effort in the development and manufacturing areas.

Modifications to the current Stirling engine would be necessary in order to meet the power quality requirement. The engine developer projects that by incorporating a flywheel, the requirements for the precise generator sets could be attained. A production Stirling engine will integrate much of the ducting into the engine block and eliminate many seals thereby reducing leakage of the working fluid. These modifications, plus others, should significantly reduce the system complexity and increase reliability.

A Stirling SLEEP program will require changes to the existing logistics support system. Significant amounts of training, materials, and support would be required to field a Stirling SLEEP generator set. However, the Stirling SLEEP will not create a new MOS.

A SLEEP generator set using the Stirling technology will meet or exceed all of the SLEEP requirements. A Stirling SLEEP system will exhibit the following key features:

Power	10 kW
Aural signature	emit no detectable signature @ 100 meters
Thermal signature	+/- 4^{o}C ambient

Volume	less than 30 ft^3
Height	less than 96 inches
Weight	less than 600.0 lb
Reliability	MTBOMF 600
	Operational Availability .95
	Mission capability 100 hour
	Continuous mission capability 360 hour

Set temperature 1508 ^{o}F (820 ^{o}C)

Efficiency 38% @ 820 ^{o}C

Transportable via existing systems

Although scaling has not been demonstrated in testing, a great potential benefit exists in this area. Altering the Stirling engine pressure level (facilitated via the working fluid) induces a change in the power level generated (kW). This enables engine standardization. In other words, by increasing or decreasing the engine working fluid pressure level, the same engine could supply 60 kW or 10 kW power without modification.

APPENDIX E

ACQUISITION STRATEGY

ANNEX F:

ACQUISITION STRATEGY

FOR THE

10 KILOWATT (kW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10kW SLEEP)

23 February 1988

US ARMY
BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

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1. PROGRAM STRUCTURE

a. General. The Army established an operational requirement for the development of a 10 kilowatt (kW) Signature Suppressed Lightweight Energy Plant (SLEEP). Tactical units need a compact, mobile electric energy plant which is difficult to detect by aural and infrared (IR) methods. The 10kW SLEEP set must be highly reliable and have a multi-fuel capability. It must produce electric power for command posts; command, control, communications, and intelligence (C^3I) systems; maintenance and logistics functions; and, other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units.

The 10kW SLEEP set will be developed and procured through an Army Streamlined Acquisition Process (ASAP) Research and Development (R&D) Program. This is the best materiel acquisition approach because the commercial market place does not manufacture power equipment which meets the Army's operational requirement. The program structure for the 10kW SLEEP set is characterized by technical feasibility testing and evaluation during the Proof of Principle Phase (PPP) and technical, user, and preproduction testing during the Development Proveout Phase (DPP). The key milestones for the program are:

(1) Technical Feasibility Test and Evaluation (TFT&E);
(2) Combined Milestone I/II In-Process Review (IPR);
(3) Technical Test (TT);
(4) User Test (UT);
(5) Procurement Authorization (PA) Initiation IPR;
(6) Preproduction Test (PPT);
(7) Milestone III IPR;
(8) Type Classification (TC);
(9) Product Acceptance Test;
(10) First Unit Equipped Date (FUED); and,
(11) Initial Operational Capability (IOC).

The overall milestone schedule for the program is provided in Enclosure 1.

b. <u>Background</u>. The capability to operate in forward areas necessitates improved combat effectiveness and unit survivability. Therefore, the 10kW SLEEP sets will be lightweight, mobile, and difficult to detect by aural and thermal IR means. Current Army generators are extremely susceptible to aural and thermal IR detection because of their high signature profiles. Furthermore, excessive generator noise, masks sounds which degrades the defender's ability to detect intruders and enemy movement. The 10kW SLEEP set with improved reliability and low signatures will reduce the potential of endangering personnel and equipment, increase a unit's mission performance capability, and reduce the need to operate combat vehicles as a source of electrical power within critical and sensitive areas. This will improve unit concealment and reduce vehicle wear.

The 10kW SLEEP set will be fully interchangeable with generator sets of similar power rating including transportation requirements. The new generator set will be available in three modes: two Alternating Current (AC) modes, Mode II, 400 Hertz (Hz) and Mode III, 60 Hz; and one Direct Current (DC) mode, Mode IV. It will replace the existing 10kW generator set in form, fit, and function in nuclear capable delivery units and associated combat service support elements, signal units, air defense units, combat arms C^3I sections, and logistics functions in the brigade area. The 10kW SLEEP set will be introduced through the supply system to prospective users with the nuclear capable delivery units and their associated combat service support elements holding priority. The basis of issue will be determined at a later date.

c. <u>Management</u>. Management of the 10kW SLEEP procurement will be a Government and contractor team effort. The Project Manager, Mobile Electric Power (PM-MEP), US Army Troop Support Command (TROSCOM), will have overall program management responsibility. The US Army Belvoir Research Development and Engineering Center (BELVOIR) has been designated as the materiel developer by US Army Materiel Command (AMC) and will assist PM-MEP with the program. BELVOIR will be responsible for the research and development actions up to and including equipment TC. After TC, TROSCOM will have procurement, production, and readiness responsibility for the 10kW SLEEP sets.

The US Army Engineer School (USAENS) has been designated as the combat developer and proponent school by the US Army Training and Doctrine Command (TRADOC). A total contractor managed approach is not appropriate for this equipment because the SLEEP technology selection and implementation process will require numerous Government decisions and interactions with the contractor team. In addition, equipment development may require several contractors.

d. Interfaces. The 10kW SLEEP set does not compete with other Army or other service programs. Although the other services and allied countries have not shown a specific interest in this power source, Australia, Great Britain, Canada, and other North Atlantic Treaty Organization (NATO) forces are pursuing signature suppressed generators and closely monitoring development of US technologies. PM-MEP will coordinate the sharing of program and technical information in a forum to be determined at a later date.

2. CONTRACTING STRATEGY

The Total Life Cycle Competition Strategy (TLCCS) for 10kW SLEEP is built upon full and open competition. End item procurement will be competed through Requests for Proposals (RFPs) which will be advertised in the Commerce Business Daily. The type of contracts used in each phase is associated with technical risks of end item development for that phase. The technical risks for developing SLEEP hardware has been judged to be medium. Consequently, cost-reimbursement contracts will be used for development of 10kW SLEEP sets. If required, the initial provisioning for spares, repair parts, and components for the end item will be included in the solicitation document. However, initial provisioning will be priced separately from the end item and will become an item for negotiation with the contractor. When Interim Contractor Support (ICS) is needed to reinforce normal maintenance channels, it will also be priced and negotiated separately with the contractor for a specified time period. The Government will normally provide maintenance and overhaul; however, when contractor maintenance is required to support the end item, the contract will be competed.

Competitively awarded Cost Plus Fixed Fee (CPFF) contracts are planned for two PPP prototype systems of each generator mode. These prototypes will be used for the TFT&E. Upon successful testing and a positive Milestone I/II IPR decision, multiple CPFF engineering development contracts will be competitively awarded. For each generator mode, a maximum of 4 manufacturers will build prototypes, for a total not to exceed 36. These prototypes will undergo exhaustive tests during development and operational testing, and actually participate in a "shoot-off" during the process. Upon completion of testing, the results will be evaluated at an IPR conducted to approve the initiation of PA activities. These activities will include: Initial Production Facilitization (IPF), procurement of Long Lead Time Items (LLTI), development of hard-tooled prototypes, and the conduct of a Production Readiness Review (PRR). Any of the manufacturers that passed the test criteria and met the operational requirements will be selected to compete for the preproduction contracts. The objective is to have at least two manufacturers for each generator mode competing for the preproduction contracts. These contracts include development of technical data packages (TDPs) and Level 3 Drawings. Initial production operational concerns are to be evaluated during PPT. The PPT, TT, and UT results will be evaluated at the Milestone III TC IPR. Should the results lead to an approval decision during the IPR, BELVOIR will prepare the military specification and Purchase Description (PD) for the 10kW SLEEP sets. TROSCOM will develop the RFP for a Firm Fixed Price (FFP) contract and assume responsibility for the procurement, production, and readiness of the end item. The contract will cover the multi-year production of the 10kW SLEEP set; specific quantities and unit flyaway costs are not available at this time. Incentive and penalty clauses will be included in the contract to focus the contractor's efforts on quality assurance and meeting the established production rates and delivery schedules.

All qualified manufacturers will be allowed to compete for the production contracts. Based on a source selection process, the award will be made to the manufacturer(s) who: best meets the terms of the RFP, is(are) determined to be reliable and technically qualified to successfully produce the equipment, and is(are) competitive in cost.

The contractor(s) is(are) expected to provide standard manufacturer warranty coverage for the end item and its major components or assemblies. Although the breakout of components and spares will be determined at a later date, the prime contractor may be required to provide the initial provisioning and spare parts for the equipment. It is anticipated that this type of provisioning would be priced out separately from the end item.

3. TAILORING THE ACQUISITION PROCESS

Currently, the development of the 10kW SLEEP set is in the PPP. A market investigation has identified the manufacturers and suppliers that can support the program. During this phase, prototyping and the TFT&E will take place to determine if SLEEP technology and its technical applications can be integrated into a 10kW generator and satisfy expected design and performance criteria. A Milestone I/II IPR will evaluate test results and technology maturity in addition to deciding to continue research or advance the program to the next phase.

Subject to a positive decision at the Milestone I/II IPR, the 10kW SLEEP set program will be streamlined by requesting a waiver to eliminate the Demonstration and Validation Phase (DVP). Because the new 10kW SLEEP set will closely parallel the current 10kW generator and mission and operational requirements are well known, the DVP is considered unnecessary.

During the DPP, it may be possible to accelerate the process by conducting TT and UT concurrently, rather than sequentially. However, concurrent testing may require additional prototypes, whereas, sequential testing permits the use of the same prototypes for both tests. BELVOIR will coordinate between the TT and UT test agencies to facilitate concurrent testing, avoid delays, and eliminate redundant efforts.

Test results will be evaluated at the PA initiation IPR and following an approval decision, a preproduction contract will be awarded. TT, UT, and PPT data will be examined at the Milestone III TC IPR. Obtaining TC pproval will lead to the awarding of production contracts. At this time, component

availability and technical feasibility are the only obstacles anticipated which may prevent the award of production contracts within the four year objective established for a procurement of this type.

4. MANPOWER AND PERSONNEL INTEGRATION (MANPRINT)

The 10kW SLEEP set will meet the applicable human factors design described in Military Standard (MIL-STD)-1472. The 10kW SLEEP sets must be deployable under climatic designations of hot, basic, cold, and severe cold (with winterization kits) as defined in Army Regulation (AR) 70-38. The generator sets shall be capable of operation, transportation, and storage up to 8,000 feet altitude with protective shelter varying from permanent facilities to no cover. The 10kW SLEEP set must be operable and maintainable by qualified 5th percentile female through 95th percentile male soldiers, who are dressed appropriately, including arctic and nuclear, biological, and chemical (NBC) protective clothing at Mission Oriented Protective Posture (MOPP) IV. MANPRINT issues will be addressed by the Integrated Logistic Support (ILS) Management Team (ILSMT) or BELVOIR's Human Engineering Laboratory (HEL) Detachment (if related to human factors). No increase in force structure is anticipated at this time; however, new equipment training (NET) will be required to train instructors and key personnel prior to UT and PPT and in support of initial equipment fielding.

5. SUPPORTABILITY

In order to ensure that 10kW SLEEP set is properly supported before and after fielding, the design and development process must consider ILS. All design decisions will be evaluated to determine their impact on ILS so that support requirements can be identified and accommodated. TROSCOM is responsible for ILS and will prepare an ILS Plan (ILSP) to document the program and fully address total system support requirements. The following information addresses supportability issues and provides some insights on ILS.

The 10kW SLEEP set will be supported through the standard Army logistics system. The spares, repair parts, and components will be provisioned and available through normal supply channels. However, interim contractor support may be required until the equipment can be fully supported by the Army's logistics system. Establishing a combat Prescribed Load List (PLL) that will provide sufficient essential repair parts at the unit level will be considered. The overall maintenance support concept and requirements for transportability, packaging, handling, and storage will be built around the programs established for the current 10kW generator set. Any new or additional requirements, such as the security that may be needed for the 10kW SLEEP components and assemblies while in storage, will be addressed as the program develops. New facilities will not be required for this program.

In an effort to assist in the logistic support and lower the potential for problems in the field, the 10kW SLEEP set will incorporate a modular design with easily replaceable components and built-in-test-equipment (BITE). The use of tools, test equipment, and other support items currently authorized for current generator sets, will be maximized. Special tools and equipment will be minimized. A System Support Package (SSP) will be prepared by BELVOIR and validated during TT and UT. A requirement for the SSP will then be included in the production contractor's statement of work (SOW). Technical data, to include the TDP; any new test, measurement, and diagnostic equipment (TMDE); NET; and, Depot Maintenance Work Requirements (DMWR) will also be procured through the production contract. The contractor(s) will support all testing and provide commercial support literature with the equipment. The need for technical manuals will be addressed when TROSCOM develops the ILSP. There may be an option of converting commercial technical and support literature into the military format and style, or developing a new technical manual.

The Basis of Issue Plan (BOIP) which lists quantities, support equipment, personnel changes, and the Quantitative and Qualitative Personnel Requirements Information (QQPRI) which identifies operator and maintenance skills, will be initiated at a later date. The 10kW SLEEP set will not require additional personnel or a new Military Occupational Specialty (MOS).

The introduction of SLEEP technology could require special maintenance methods and procedures which may require some new skills. The use of an Additional Skill Identifier (ASI) for generator maintenance personnel will be considered at a later date. Institutional training should be minimal. NET will be required for instructors and key personnel prior to UT and PPT and to support the initial fielding of the equipment. The BOIP and QQPRI will confirm the personnel and skill training requirements for the program. The specific requirements then will be included in the ILSP.

The warranty program for 10kW SLEEP set, its major components and assemblies will be specified in each contractor's SOW. Warranty coverage will include, but not be limited to, workmanship and material defects; performance capabilities; and reliability, availability, maintainability, and durability (RAM-D) objectives.

6. MANUFACTURING AND PRODUCTION

A market investigation revealed an industrial base to support manufacturing and production requirements. After a successful TT, UT, and PPT, and a positive decision at the Milestone III TC IPR, a solicitation document can be issued for the subsequent award of planned multi-year production contracts. The specific production quantities and the economic production rate for the equipment will be determined at a later date. No adverse impact is expected on the defense industrial base because of this procurement. A surge capacity, when required, can be accommodated by the contractor employing multiple shifts. Surge capability would increase dramatically if more than one vendor was selected for production.

The 10kW SLEEP set will maximize the use of commercially available parts and components, and standard manufacturing processes and systems. Since the equipment will use new technology that is considered within the state-of-the-art, a medium production risk has been assessed for the program. This risk is primarily associated with achieving low aural and IR signatures within the equipment's size and weight constraints. Special manufacturing techniques will be minimized, should they be required. Producibility

Engineering Planning (PEP) will take place throughout the development cycle to ensure an efficient transition to production. BELVOIR is responsible for PEP and will develop the strategy and necessary plans to produce the 10kW SLEEP set economically and in a timely manner. Value Engineering (VE) will be included in the production contract as an incentive clause for any techniques which improves basic designs, lowers costs, and maintains system performance levels.

Quality production is critical to the successful materiel acquisition and fielding of reliable equipment. Throughout the Production and Deployment Phase (PDP), quality assurance will be achieved through controls, checks, and tests. At minimum, the Product Acceptance Test will include: a Final Functional Configuration Audit (conducted before production), a Final Physical Configuration Audit (conducted early in production), and a First Article Test. Each SOW will include specific product quality requirements.

7. TEST AND EVALUATION

Major testing for the 10kW SLEEP set will include TFT&E consisting of a Technical Demonstration and a Troop Demonstration, and if time is critical, concurrent rather than sequential TT and UT during DPP. Single TT and UT tests will be conducted since a request will be submitted to eliminate the DVP of the traditional R&D life cycle to adhere to current ASAP guidance. The exact scope and type of testing needed may vary depending upon the maturity of the technology used in the prototypes. TFT&E will be oriented toward evaluating 10kW SLEEP components or system capability to reduce the aural and thermal IR signatures of the 10kW generator set. The more extensive TT and UT tests will be conducted by the US Army Test and Evaluation Command (TECOM) and the US Army Operational Test and Evaluation Agency (OTEA), respectively. These tests will evaluate the prototypes using the essential characteristics defined in the requirements document using Army personnel under realistic operational conditions. The results of TT and UT will be used in the development of preproduction units for the PPT. PPT shall be conducte y OTEA and geared toward assessing the quality of production tooling the manufacturer(s) use; validity of system design;

adequacy of technical manuals and other system documentation; and, assuring prudent production. All aspects of the new equipment must be properly tested and evaluated prior to procurement, production, and fielding. The actual dates and locations for these tests will be determined at a later date.

The critical issues, specific test procedures, and the number of prototypes to be tested will be included in the Test and Evaluation Master Plan (TEMP) for the program. The TEMP has been developed and will be approved by the Test Integration Working Group (TIWG) at a later date. The chairman of the TIWG is responsible to identify critical issues that must be tested in certified facilities. Certification requirements will be made a matter of record and included in the TEMP and all development, preproduction, and production contracts. Guidance for development of the SSP and Test Support Package will be provided in the TEMP.

Product Acceptance Testing will be conducted to determine each production contractor's ability and performance in producing 10kW SLEEP sets that meet established technical and operational specifications. The Product Acceptance Test will be conducted at contractor and Government facilities.

8. COST GROWTH AND DRIVERS

The 10kW SLEEP design will make maximum use of commercially available and military standard components. The 10kW SLEEP program will maintain a design-to-cost approach throughout development focusing on R&D, manufacturing, and operations and support. Cost goals will be established early in the program and addressed at all IPRs.

The technology required for the 10kW SLEEP set to meet its signature suppression, size, weight, and survivability specifications is considered to be within the state-of-the-art. Therefore, the principal cost drivers are expected to be associated with components and technology integration. Specific cost and growth drivers will be developed at a later date.

9. TECHNICAL RISKS

Studies conducted by the Army and other agency development activities conclude that the proposed non-detectable power source is feasible and within the state-of-the-art for a number of advanced energy conversion technologies. However, the 10kW SLEEP set size and weight must be compatible with currently authorized transportation capabilities and configuration restrictions. It must have minimal impact on the mobility of the supported system or unit. Design targets should not exceed the size and weight range of the standard 10kW mobile electric power gasoline engine driven set (GED). Technologies which inherently exceed the standard GED size and weight must exhibit significant RAM-D and signature advantages to offset mobility impacts. The difficult problem facing the 10kW SLEEP involves meeting the low aural and thermal signature requirements, while remaining within the stated size (30 cubic feet) and weight (650 pounds) constraints. The specific technology needed to meet these requirements has been identified as Kinematic Sirling. Additional requirements dictate survival of NBC attack, fire, blast, and other similar agents or events. These requirements hold lower priority than the signature suppression requirement. Based upon the aforementioned Army study conclusion, the state-of-the-art 10kW SLEEP program has been given a medium risk level due to the yet unproven technology.

10. HUMAN FACTORS ENGINEERING (HFE), SAFETY, AND HEALTH

The 10kW SLEEP set must conform to applicable health and safety requirements and accepted human factors criteria. In order to meet this objective, safety and health issues must be addressed at all stages of development and testing. Special attention must be given to: NBC, fuel, electrical, and fire hazards; transportation safety (tie down procedures); external moving parts; exhaust gases; and, selected human factors, such as eliminating sharp corners, burred edges, and high temperature surfaces. Further, the 10kW SLEEP set must present no uncontrolled health hazards to personnel and, as a minimum, must adhere to MIL-STD-882B and AR 40-10. The BELVOIR Human Engineering Laboratory (HEL) Detachment will provide assis-

tance to the BELVOIR contracting officer or his representative in matters relating to HFE per BELVOIR Standard Operating Procedures (SOP) 70-18 (Research and Development, Human Factors Engineering, October 15, 1985). HFE shall be an ongoing process which begins with the HEL Detachment review and continues throughout the system life cycle.

As part of the design process, safety and health problems of existing generator systems will be analyzed in order to avoid potential hazards. Engineering change proposals (ECPs) that may develop during design or production will be reviewed to determine whether they may adversely impact personnel and equipment safety. BELVOIR will be required to develop a System Safety Program which includes a Safety Assessment Report (SAR) and Health Hazard Assessment (HHA). A Safety release will be prepared prior to testing. It is expected that few, if any, potential hazards will have to be accepted.

11. RATIONALIZATION, STANDARDIZATION, AND INTEROPERABILITY (RSI)

No RSI problems are expected at this time. The other services and allies have shown little interest in the development and acquisition of the 10kW SLEEP sets. However, Australia, Great Britain, Canada, and other NATO forces are pursuing other signature suppressed generators and are closely monitoring the development of US technologies. The exchange of signature suppression data and program information will be coordinated by PM-MEP.

12. SURVIVABILITY AND ENDURANCE

The 10kW SLEEP set must be capable of operation anywhere that US forces may be deployed including difficult terrain conditions and climatic categories of hot, basic, cold, and severe cold. Weapons posing a threat to the equipment include small arms, artillery, missiles, saboteurs, airborne and heliborne units, directed energy systems, unconventional warfare (UW) teams, and special purpose forces. Operational threats include aural and thermal detection and NBC attack. The 10kW SLEEP operational environments include: extreme cold, extreme heat, high altitude electromagnetic pulse (HAEMP),

high humidity, fungus, rain, salt fog, shock conditions, and snow. The 10kW SLEEP set will be capable of being internally transported in United States Air Force (USAF) C-130 and C-140 aircraft, externally transported by US Army helicopters, and, when suitably packaged, delivered by low velocity air drop (LVAD) and low altitude parachute extraction (LAPES) from USAF aircraft. NBC contamination and decontamination survivability are required and will be enhanced with Chemical Agent Resistant Coating (CARC). In general, the 10kW SLEEP set should be as survivable as the typical systems and units it supports.

The 10kW SLEEP set will be used in missions requiring high reliability and low signature. These missions can range up to 360 hours of continuous operations. On a typical 24 hour mission, the 10kW SLEEP set, with vehicle backup power, will be expected to operate for a total of 21.25 hours; the remaining time is allocated for one move per day of 1.5 hours and five maintenance periods per day of 0.25 hours each. The 10kW SLEEP set should have a nominal non-detectability distance of approximately 100-300 meters. With its surface area 90% exposed, it should produce no image temperature (star signature) more than ±4° Celsius from the average ambient background temperature. A table of RAM-D objectives for the 10kW SLEEP set is provided in Enclosure 2.

13. ELECTRIC POWER AND ENVIRONMENTAL CONTROL EQUIPMENT

Since the 10kW SLEEP generator is not a consumer of electric power, if does not fall under the purview of MIL-STD-XXX (Military Standard Mobile Electric Power Engine-Generator Standard Family Selection Guide, dated 15 November 1985). The Proposed MIL-STD requires assessment of electrical power requirements of consuming equipment in order to make the best overall use of military generator sets.

14. SHORT - TERM ISSUES

There are no short term issues at this time.

ENCLOSURE 1: MILESTONE SCHEDULE

ACTIVITIES AND EVENTS	DURATION ONCE INITIATED
Program Initiation	
Requirements and Technology Base Activity	
Materiel Acquisition Review Board (MARB)	
Proof Of Principle Phase (POP)	1-2 Years
Market Investigation	3 Months*
Verify Design and Engineering	3 Months*
Functional Purchase Description (PD)	6 Months*
Prototype Components/System	12 Months
Technical Demonstration	3 Months
Troop Demonstration	3 Months
Milestone I/II In-Process Review (IPR) (Go - No Go)	
Development and Production Proveout (DPP)	4 Years
Prototype System	18 Months
Technical Test and Evaluation	6 Months
User Test and Evaluation	6 Months
PD	6 Months*
Complete Technical Data Package (TDP)	6 Months*
Procurement Appropriation (PA) Initiation IPR	
Initial Production Facilitization (IPF)	6 Months*
Procure Long Lead Time Items (LLTI)	1 Month *
Preproduction Test (Hard-Tooled Prototypes)	6 Months
Production Readiness Review (PRR)	1 Month
Production Solicitation Document Developed	6 Months*
Milestone III Type Classification (TC) IPR	
Production and Deployment Phase (PDP)	
Product Acceptance Test	
First Article Test (FAT)	
First Unit Equipped (FUE) (Materiel Release)	
Initial Operational Capability (IOC)	

NOTES:

1. The dates with * are events that can be scheduled concurrently during the PPP and DPP.

2. The streamlined approach is based on mature technology and low risk, which are confirmed by technical reports, engineering analysis, and/or Market Investigation. The Milestone I/II IPR will decide on continued research or advancing the program to the next phase.

ENCLOSURE 2: RELIABILITY, AVAILABILITY, MAINTAINABILITY, AND DURABILITY (RAM-D) OBJECTIVES

CATEGORIES		OBJECTIVES
a.	Operational Availability	
	Minimum Acceptable Value (MAV)	95%
	Best Operational Capability (BOC)	97%
b.	Mean Time Between Operational Mission Failure (MTBOMF)	
	MAV	400 hrs
	BOC	600 hrs
c.	Administrative Downtime (Based On 24 Hours)	6.3%
d.	Maintenance Downtime (Based On 24 Hours)	5.2%
e.	Maintenance Ratio	
	Organizational	0.065
	Direct Support	0.035
	General Support	0.022

APPENDIX F

CONCEPT FORMULATION PACKAGE

CONCEPT FORMULATION PACKAGE (CFP)

FOR

10 KILOWATT (KW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10 KW SLEEP)

DRAFT

February 23, 1988

PREPARED FOR THE

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

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CONCEPT FORMULATION PACKAGE

1. INTRODUCTION.

This Concept Formulation Package (CFP) documents the concept exploration effort for the 10 kilowatt (kW) Signature Suppressed Lightweight Electric Power Plant (10kW SLEEP). The system will be capable of providing electric power for command posts; command, control, communications, and intelligence (C^3I) systems; maintenance and logistics functions; and other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units. The CFP develops and analyses the technical, schedule and economic alternatives for the acquisition of a 10kW SLEEP, and describes the rationale for the selection of a preferred technical approach.

2. SYSTEM DESCRIPTION.

a. What the system is. The 10kW SLEEP will be an electric power plant that can deliver 10 kW of electric power to US Army tactical units. It will be lightweight, mobile and difficult to detect by aural and thermal infrared (IR) means. It will be highly reliable and have a multi-fuel capability.

b. What is it intended to do. The 10kW SLEEP sets will supply electrical power of acceptable quality and output for units requiring highly reliable generators which exhibit low battlefield signatures for successful mission accomplishment and survivability. The 10kW SLEEP will be fully interchangeable with the current 10kW power generating equipment of the same mode.

c. Threat environment in which it will operate. The 10kW SLEEP will be used in all warfare conditions (including nuclear, biological and chemical (NBC)) and all phases of peacetime training. Weapons posing a threat to the set include small arms, artillery, missiles, saboteurs, airborne and heliborne units, directed energy systems, unconventional warfare (UW) teams and special purpose forces. The 10kW SLEEP will be exposed to the same threat environment as the typical systems and units it supports.

d. Performance Characteristics. The 10kW Sleep will be capable of providing 10kW of electrical power to tactical units. It will provide 60 Hertz (Hz) and 400 Hz alternating current (AC) and direct current (DC) power conforming to the performance standards of MIL-STD-1332. Compared with the current 10kW generator sets, it will have lower aural and thermal IR signatures and improved reliability. It will be capable of operation in all climatic conditions, hot, basic, cold, and severe cold as described in Army Regulation (AR) 70-38. It will be fully transportable by strategic and tactical transportation modes. It will be high altitude electromagnetic pulse (HAEMP) hardened and NBC contamination/decontamination survivable. It will have multi-fuel capability and not require petroleum, oil, or lubricants not already in the supply system. The performance requirements of the 10 kW SLEEP generator sets are fully described in function Purchase Description (PD) for the Generator Set, Quiet 10kW dated 20 November 1987.

e. New or Unusual Features. The 10kW SLEEP will be multi-fueled and will incorporate technologies which improve system reliability, interchangeability, survivability in environmental extremes, maintainability, supportability, safety, weight, size and transportability. The sets will have suppressed aural and thermal IR battlefield signatures; NBC contamination/decontamination survivability; and HAEMP hardening.

f. Operational and Organizational Concept. Since the 10kW SLEEP must produce electric power for command posts; C^3I systems; maintenance and logistics functions; and other support activities where high reliability, mobility and signature suppression are essential, a 10kW SLEEP capability becomes mission essential. The system will be used in high to low intensity conflicts so it must be effective in all anticipated tactical conditions. It must be capable of movement by all strategic and tactical transportation means. It must have a low operational signature to reduce detection and hardened against the threat environment discussed in section b above. It must be multi-fueled, capable of continuous operation; and have improved reliability, availability, maintainability and durability (RAM-D) characteristics. The operator will perform maintenance with a minimum of higher level support.

Organizationally, the 10kW SLEEP will replace the existing 10kW generator set in form, fit and function in nuclear delivery units and associated combat service support elements, signal units, air defense units, combat arms C^3I sections, and logistics functions in the brigade area. The 10kW SLEEP set will be introduced through the supply system to prospective users with the nuclear delivery units and their associated combat service support elements holding priority. The basis of issue will be introduced at a later date.

g. Operational Mode Summary/Mission Profile. The 10kW SLEEP is expected to support continuously command posts; C^3I systems; maintenance and logistics functions; and other support activities. The operational mode summary for a typical 24 hour mission follows:

Administrative downtime	1.50 hours
Maintenance downtime	1.25 hours
Operation at demand levels	21.25 hours.

The operational mode summary for 15 day intense wartime mission follows:

Task	Time Each Day (hours)	Total Time (hours)
Operating Time	21.5	322.5
Standby Time	1.0	15.0
Movement Time	1.5	22.5.

The system will operate in hot, basic, cold, and severe cold environments.

h. Logistic Support Concept. The 10kW SLEEP set will be supported through the standard Army logistics system. Spares, repair parts, and components will be provisioned and available through normal supply channels. The overall maintenance support concept and requirements for transportability, packaging, hardening, and storage will be built around the programs established for the current 10kW generator set. The 10kW SLEEP will employ a modular design with easily replaceable components and built-

in-test-equipment (BITE). The use of tools, test equipment, and other support items currently authorized for current generator sets, will be maximized. Special tools and equipment will be minimized.

i. Life Cycle Cost Estimates. Life cycle cost (LCC) for the 10kW SLEEP is $130.4M, which is thought to be more than that of the current 10kW generators. This projection is based on reduced signatures and system weights.

j. Estimation of Manpower Requirements. No increase in force structure is anticipated at this time; however, new equipment training (NET) will be required to train instructors and key personnel prior to User Test (UT) and to support initial fielding of the system.

k. Systems Being Replaced. The 10kW SLEEP will replace the existing 10kW generator set in form, fit and function.

l. Competing Systems. The 10kW SLEEP does not compete with other Army or other service programs.

m. Reliability, Availability, Maintainability, and Durability (RAM-D). Following is a list of 10kW SLEEP RAM-D requirements:

Reliability
- Mean Time Between Opeational Mission Failure (MTBOMF) (hours)
  600 Best Operational Capability
- MTBOMF (hours)
  400 Minimum Acceptable Value

Maintainability
- Maintainability Ratio (MR) unit 0.05

Operational Availability Objectives
- A (war) 0.95
- A (peace) 0.95

APPENDICES

A. Trade-Off Determination (TOD)

B. Trade-Off Analysis (TOA)

C. Best Technical Approach (BTA)

D. Cost and Operational Effectiveness Analysis (COEA)

APPENDIX A

TRADE-OFF DETERMINATION (TOD)

FOR

10 KILOWATT (kW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10 kW SLEEP)

DRAFT

February 23, 1988

PREPARED FOR THE

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
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1. DESCRIPTION OF TECHNICAL APPROACHES.

a. Overview. The full range of technical approaches was evaluated for the development of the 10kW Signature Suppressed Lightweight Electric Energy Plant (10kW SLEEP). These approaches were:

- Retain current equipment
- Product improvement (PI)
- Non-developmental item (NDI)
- Standard materiel acquisition cycle
- Tailored materiel acquisition cycle.

Each of the approaches are briefly discussed in the following paragraphs.

b. Retain current system. The existing 10kW generator sets were standardized in the early 1970's, and represent aged technology and conservative engine and generator design. There have been repeated complaints from units employing generators that the acoustic and thermal infrared (IR) signatures are too "loud" and too "hot". Improvements by threat forces in aural and thermal IR detection sensor technology place units operating these generator sets in increased risk of detection. Advanced signature analysis can accurately predict the function, echelon of deployment, and relative importance of tactical units operating these generators. Furthermore, the high aural signatures can mask the sounds of approaching enemy forces and disrupt operator concentration. In addition to the high operational signatures, other deficiencies of the current 10kW generators are:

- low reliability
- high logistic support requirements
- cumbersome petroleum, oil and lubricant (POL) requirements
- approximately one-half of the current 10kW generators have exceeded their design life.

Changes in doctrine, training and/or organization will not overcome the

current 10kW generator deficiencies.

c. Product Improvement (PI). Preliminary engineering assessments indicate that PI will not overcome the deficiencies of the current system. Technological advances in the area of electrical power generation have occurred since the initial fielding of the current 10kW generators. However, these advances are incapable of achieving the desired performance within the framework of the current system because of the difficulty in applying these advances to the current equipment. It is estimated that improvement of currently fielded systems would do little to reduce weight, size, operational signature, logistic support or reduce the POL requirements. The extensive improvements required in performance and costs are best satisfied through a structured engineering research and development program which will take advantage of technological advances.

d. Non-developmental Item (NDI). There is a limited likelihood for an off-the-shelf procurement of a 10kW SLEEP capability. Assessment of technical literature indicates that manufacturers of electric power generators have little interest in developing integrated systems for purely military purposes. However, there appear to be numerous firms interested in using off-the-shelf components developed for the commercial market as the foundation of a 10kW SLEEP capability. This concept would permit use of the components for military applications such as 10kW SLEEP, as well as for high volume commercial sales.

Development of this nature cannot be described as NDI, as the function and configuration of the final system would be unrelated to that of the off-the-shelf products. To achieve the desired 10kW SLEEP capability would require extensive design, engineering, fabrication, and, testing which more aptly characterizes a tailored materiel acquisition cycle.

In summary, the NDI concept is not considered the most viable approach for 10kW SLEEP. Equipment with the 10kW SLEEP capability is not easily found in the commercial or military market. However, assessment of component developments in the fields of electric power generation, signature

suppression and nuclear, biological and chenical (NBC) contamination/decontamination survivability should continue because of the potential to engineer the integration of NDI components in a unit that will meet 10kW SLEEP requirements.

e. Standard Materiel Acquisition Cycle. A standard materiel acquisition cycle can produce the desired 10kW SLEEP capability. Such an approach however, would not take advantage of the commercial interest and work in improving the capabilities of electric power generators. Technological advances and on-going research and development in miniaturization, modular components, increased reliability, and better fuel efficiency can result in enhanced 10kW SLEEP capabilities without the need for a full scale development effort. The current 10kW SLEEP program should focus on the integration of the major functional elements by using the most promising components for better efficiency and reliability, and optimal configuration to meet weight and volume specifications. Given the level of interest and capability that is readily available in the commercial market, the standard materiel acquisition cycle should not be pursued.

f. Tailored Materiel Acquisition Cycle. A tailored materiel acquisition cycle appears best suited for acquiring a 10kW SLEEP capability. Although a considerable engineering effort will be necessary to develop a program that meets Army requirements, the level of risk (technical, schedule, and cost) appears to be medium given the technological maturity of current products and components, and the availability of technical solutions, expertise and capabilities of private industry.

The preferred materiel acquisition cycle is the Army Streamlined Acquisition Process (ASAP) Research and Development (R&D) Program. The ASAP allows the acquisition to be tailored to the unique characteristics of the 10kW SLEEP program which accelerates and simplifies the acquisition. It is characterized by technical feasibility testing and evaluation during the Proof Of Principle Phase (POP) and technical, user, and preproduction testing during the Development Proveout Phase (DPP).

The 10kW SLEEP set program will be streamlined by requesting a waiver to eliminate the Demonstration and Validation Phase (DVP). Because the new 10kW SLEEP set will closely parallel the current generator and mission understanding and operational requirements are well known, the DVP is considered unnecessary.

During the Development Proveout Phase, it may be possible to accelerate the process by conducting Technical Test (TT) and User Test (UT) concurrently, rather than sequentially.

2. EVIDENCE THAT THE PROPOSED TECHNICAL APPROACH IS ENGINEERING RATHER THAN EXPERIMENTAL.

There is a wealth of data available which relate to electric power generation. Information on the industry's technological base indicates a variety of technical options that could be pursued for 10kW SLEEP development. Important technologies include combustion cycles (diesel, Stirling, Brayton/gas turbine), and fuel cells. These mature technologies demonstrate that the proposed technical approach is engineering rather than experimental.

3. TRADE-OFFS FOR THE SUGGESTED APPROACH.

The principal trade-off for the suggested approach is the amount of risk (cost, schedule, and technical performance) which can be accepted. A standard materiel acquisition cycle would be the least risky of the technical approaches. If problems are discovered during the standard materiel acquisition cycle, they can be carefully evaluated and normally corrected without severe impact upon schedule. However, the standard materiel acquisition cycle entails the greatest expenditure of time and other resources. The tailored materiel acquisition cycle reduces time and dollar requirements, but somewhat increases the level of risk. Areas of concern regarding technical risk under all options are:

- Reducing operational signature
- Meeting weight and volume specifications
- Achieving reliability, availability, maintainability, and durability (RAM-D) objectives
- Obtaining improved fuel efficiency
- Meeting environmental constraints
- Attaining procurement and life cycle cost goals
- Meeting survivability requirements
- Meeting transportability requirements
- Meeting electrical performance goals

4. ESTIMATED LIFE CYCLE COST AND SCHEDULE.

a. Life Cycle Cost (LCC). The total life cycle cost of the 10kW SLEEP is estimated at $130.4M in fiscal year (FY) 88 dollars.

b. Schedule. The schedule for the development of the 10kW SLEEP is to be determined.

5. RECOMMENDED TECHNICAL APPROACH.

Therefore, in light of the preceding discussion, the recommended approach is a tailored materiel acquisition cycle, accelerated to provide a near-tern solution to current deficiencies in 10kW mobile, electric power generation.

APPENDIX B

TRADE-OFF ANALYSIS (TOA)

FOR

10 KILOWATT (kW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10 kW SLEEP)

DRAFT

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1. MISSION AND PERFORMANCE.

The Army established an operational requirement for the development of a 10 kilowatt (kW) Signature Suppressed Lightweight Energy Plant (SLEEP). Tactical units need a compact, mobile electric energy plant which is difficult to detect by aural and infrared (IR) methods. The 10kW SLEEP set must be highly reliable and have a multi-fuel capability. It must produce electric power for command posts; command, control, communications and intelligence (C^3I) systems; maintenance and logistics functions; and, other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units.

The Army currently employs 10kW electric energy generators which are extremely susceptible to aural and thermal IR detection because of their high signature profiles. The current system also has low reliability, requires high logistic support, has cumbersome petroleum. oil and lubricant (POL) requirements, and approximately one-half of them have exceeded their design life. 10kW SLEEP will significantly enhance capabilities over the current generators.

The 10kW SLEEP requirements are as follows:

- Reduce operational signature
- Meet weight and volume specifications
- Achieve reliability, availability, maintainability, and durability (RAM-D) objectives
- Obtain improved POL requirements
- Meet survivability requirements
- Meet transportability requirements
- Meet electrical performance goals.

The supporting rationale for these requirements is 10kW SLEEP's need to be operational in a broad range of critical missions, often under conditions of limited logistical support. Because 10kW SLEEP is critical to mission

performance, it must have low operational signature and high survivability.

Specific information on 10kW SLEEP requirements is provided below, in the form of anticipated mission performance envelopes (MPEs). The acquisition alternatives to achieve these requirements in the development of 10kW SLEEP are compared in paragraph 2, Analsyis of System Trade-Offs. Critical MPE's and supporting rationales are provided below:

- Improved weight, volume and transportability. 10kW SLEEP must be light, compact and easily transportable. The volume must be no more than 30 cubic feet. The maximum height is 96 inches and the maximum weight is 650 pounds. The maximum total weight is 1400 pounds and the maximum tongue weight is 200 pounds. It must be rugged and vibration- and shock-resistant to withstand transportation and rough field handling. It must be transportable by highway, cross-country, rail, sea, helicopter, C-130 and C-140 aircraft. It must have a low velocity air drop capability and a low altitude parachute extraction capability. 10kW SLEEP will reduce the logistical burden and ensure its transportability and availability under all anticipated operational environments.

- Reduced support requirements. 10kW SLEEP must be capable of operations and maintenance under all anticipated tactical scenarios within the parameters of standard Army logistical support policies and procedures. System design should minimize support requirements in terms of non-standard tools, parts, materials, procedures and training. The system must be capable of prolonged operation with minimum need for maintenance.

- Improved RAM-D. The unit should be designed with a reliability goal of 600 hours mean-time-between failure (MTBF). A high percentage of failures should be correctable at operator level and all maintenance should be possible by personnel dressed in NBC protective clothing, including Mission Oriented Protective Posture (MOPP) IV. The unit should have the lowest possible mean-time-to-

repair (MTTR). Design must be in accordance with the standard Army maintenance policy. Design will stress ease of maintenance and accessibility to assemblies or components that require most frequent servicing, and will employ modular replacement parts, and built-in-test-equipment (BITE) where appropriate. 10 kW SLEEP must operate for long periods of time with little attention or support required.

- Capability for worldwide use. 10kW SLEEP must be capable of operation during all phases of supported system operation over the range of worldwide climatic conditions, including use in hot, basic, cold and severe cold climates. It must produce 10kW of electrical power of acceptable quality and output. The system must insure operator safety and protection under all anticipated conditions for all geographical conditions for all geographical areas of potential Army deployment and operation.

- Reduced signature and improved survivability. The set should minimize detectability by aural and thermal IR means. Detectability characteristics should be less than those of the current 10kW generator. Aural detection must not be possible from 100 meters or less from the 10kW SLEEP. The thermal IR signature must not be greater than ± 4°C from ambient background with 90% exposed surface area. 10kW SLEEP must be hardened against high altitude electromagnetic pulse (HAEMP). The rationale is that by reducing the system's detectability, survivability under anticipated battlefield conditions will be enhanced.

- Petroleum, Oil and Lubricant Requirements. The 10kW SLEEP must be multifueled and not require petroleum, oil or lubricants that are not already in the supply system. It will have an onboard fuel tank with an 8 hour operation capability. The rationale is to reduce the logistical burden, thereby enhancing sustained generator operation.

2. ANALYSIS OF SYSTEM TRADE-OFFS.

This section provides a preliminary evaluation of the system trade-offs for the 10kW SLEEP program. Figure 1 is a comparison of risks and other trade-offs associated with the different acquisition alternatives. The appropriate acquisition approaches are a standard materiel acquisition cycle and a tailored materiel cycle. Other approaches were either eliminated or considered not viable for the 10kW SLEEP program (reference Trade-Off Determination (TOD)). The trade-off categories are technical, cost, and schedule risks; and logistical support, and manpower impact.

RISK CATEGORIES	STANDARD MATERIEL ACQUISITION CYCLE	TAILORED MATERIEL ACQUISITION CYCLE
A. Technical	Low	Medium
B. Cost	High	Low-Medium
C. Schedule	Medium	Low-Medium
D. Logistical Support	Low-Medium	Low-Medium
E. Manpower Impact	Low	Low

Figure 1. Comparison of Acquisition Alternative Risks.

- Standard Materiel Acquisition Cycle - Select a proven technology for a standard development sequence until a satisfactory 10kW SLEEP design is developed.

- Tailored Materiel Acquisition Cycle, (Army Streamlined Acquisition Process (ASAP)) - Pursue a developmental process in which all activities and decision points exits, but are compressed in order to field 10kW SLEEP expeditiously. This approach offers maximum flexibility and could permit the use of multiple contractors pursuing alternative technological approaches, if necessary.

a. Technical Risk. The lowest technical risk would entail pursuing the standard materiel acquisition cycle. This approach provides the time and resources to design, analyze, and test the operational 10kW SLEEP concept thoroughly. Use of the tailored materiel acquisition cycle would offer a slightly greater technical risk due to the compression effect and time sequencing of the program.

b. Cost Risks. The cost associated with the standard materiel acquisition cycle will be higher due to the complexities of a complete, time-consuming developmental process. Cost risk will also be higher due to uncertainties regarding technical developments. Cost risks associated with the tailored materiel acquisition cycle approach are considered to be less due to reduced time in the developmental cycle and a firmer estimate of actual systems/components due to greater technology maturation.

c. Schedule Risk. As in the case of the cost risks, the standard materiel acquisition cycle will have greater schedule risks due to its inherently longer time frame. The tailored materiel acquisition cycle would experience reduced risks than would the standard materiel acquisition cycle because of the potential to accelerate the fielding of 10kW SLEEP.

d. Logistical Risks. Logistical risks associated with the standard materiel acquisition cycle and tailored acquisition cycle are somewhat comparable. Both alternatives will develop of cohesive, well-structured support concept, which in itself lowers the risk. However, because NDI components are not developed to conform to a military specification, there could be problems (risks) in fully integrating them into a logistical support concept. For this reason, the tailored approach has a slightly higher risk than the standard approach.

e. Manpower Impact. There will be a low risk of significant manpower impact on both alternatives. The human engineering interface will be about the same for these alternatives and both will have a lower manpower impact than the systems currently fielded.

3. SELECTION OF THE BEST APPROACH.

The best approach for the development and fielding of a 10kW SLEEP set from an operational and integrated logistics approach is a tailored materiel acquisition cycle (ASAP). This tailored approach would be as accelerated as possible by concurrent developmental activities, compression of the testing cycles and certain developmental activities, and parallel efforts by multiple contractors. This approach is designed to provide a near-term solution. A more detailed description of the structure and elements of this best technical approach is presented in the TOD. No environmental/ecological problems are expected as a result of fielding of 10kW SLEEP. Adequate health and safety considerations will guide the development of 10kW SLEEP. Human factors and human engineering considerations will be an integral part of system design.

APPENDIX C

BEST TECHNICAL APPROACH (BTA)

FOR

10 KILOWATT (kW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT (10 kW SLEEP)

DRAFT

February 23, 1988

PREPARED FOR THE

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1. DESCRIPTION OF THE BEST TECHNICAL APPROACH.

Based on the Trade-Off Determination (TOD) and the Trade-Off Analysis (TOA), the best technical approach for the development of a 10kW Signature Suppressed Lightweight Electric Energy Plant (10kW SLEEP) is the Army Streamlined Acquisition Program (ASAP). This approach offers considerable program flexibility based on the degree of technological maturity, and permits fielding of 10kW SLEEP sooner than the standard materiel acquisition cycle. Integrated Logistical Support (ILS) concepts for 10kW SLEEP will stress compatibility with the standard Army maintenance concept, and to the greatest extent possible, the use of standard parts, components, supplies, and test equipment. The US Army Troop Support Command (TROSCOM) and US Army Belvoir Research, Development and Engineering Center (BELVOIR) will conduct the Logistic Support Analysis effort and be responsible for the development of technical data, manpower, training and other important factors for the Integrated Logistic Support Plan (ILSP).

2. EVIDENCE THAT THE BEST TECHNICAL APPROACH IS ENGINEERING RATHER THAN EXPERIMENTAL.

A system that can meet 10kW SLEEP functional requirements does not currently exist in the commercial market nor is under development by private industry. There is a wealth of data which relate to electric power generation. Information on the industry's technological base indicated a variety of technical options that could be pursued for 10kW SLEEP development. Important technologies include combustion cycles (diesel, Stirling, Brayton/gas turbines), and fuel cells. These mature technologies demonstrate that the proposed technical approach is engineering rather than experimental.

3. ESTIMATED COSTS, PROCUREMENT, TOTAL ARMY MANPOWER REQUIREMENTS AND SCHEDULING.

The Research and Development (R&D) cost is estimated at $8,970K for the Advanced and Engineering Development efforts. This effort is based on the

assumption that the 10kW SLEEP will utilize new technologies requiring significant development. The Procurement cost, including Military Construction which is $0, is estimated to be approximately $32.6M. The sustainment cost, including fielding, is estimated to be approximately $88.7M. The total life cycle cost of 10kW SLEEP is estimated at $130.4M.

4. RECOMMENDATION ON PROJECT MANAGEMENT.

Management of the 10kW SLEEP procurement will be a Government and contractor team effort. The Project Manager, Mobile Electric Power (PM-MEP) will have overall program management responsibility. The use of competition and performance incentives will be considered for all phases of the contractual effort. Contracting techniques will include time phased, sequential and concurrent contracts, as appropriate.

5. ENVIRONMENTAL IMPACT STATEMENT (EIS).

There will be no adverse environmental effects from 10kW SLEEP. Therefore, an EIS is not required.

APPENDIX D

COST AND OPERATIONAL EFFECTIVENESS ANALYSIS (COEA)

FOR

10 KILOWATT (kW)

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10 kW SLEEP)

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1. INTRODUCTION.

The Army established an operational requirement for the development of a 10 kilowatt (kW) Signature Suppressed Light Weight Energy Plant (10 kW SLEEP). Tactical units need a compact, mobile electric energy plant which is difficult to detect by aural and infrared (IR) methods. The 10kW SLEEP set must highly reliable and have a multi-fuel capability. It must produce electric power for command posts; command, control, communications, and intelligence (C^3I) systems; maintenance and logistics functions; and, other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units.

2. PURPOSE.

This analysis will evaluate alternative systems that may satisfy the electrical power requirements for the 10kW SLEEP.

3. ANALYSIS.

a. Mission Needs, Deficiencies and Opportunities.

(1) Mission Needs. There is a requirement for a mobile electric energy plant which provides electrical power of acceptable quality and output for units requiring highly reliable generators. The set should use the best technology available to reduce weight, size, noise, complexity, and costs. The system must be easily transportable and have a low operational signature to reduce detectability. It should be hardened against weapons used in intense combat which could include nuclear, biological, and chemical (NBC) warfare. It should also be hardened against high altitude electromagnetic pulse (HAEMP). The system must demonstrate improved reliability, availability, and durability (RAM-D) characteristics; use standard tools, parts, and components as much as possible; and, be fuel efficient.

(2) Deficiencies. The existing 10kW generator sets represent aged technology and conservative design. There have been repeated complaints from units employing generators that the acoustic and thermal IR signatures are too "loud" and too "hot". There is a need to improve the RAM-D, transportability, petroleum, oil, and lubricant (POL), and survivability characteristics.

(3) Opportunities. An electric power plant that will meet 10kW SLEEP requirements is not available at this time. However, there appear to be numerous firms interested in using off-the-shelf components developed for the commercial market as the foundation of a 10kW SLEEP capability. There have been advances in combustion cycles (diesel, Stirling, and Brayton/gas turbine), and fuel cells. Mature and proven technologies are available for the development of 10kW SLEEP.

b. Threat and Operational Environments.

(1) Threat. The 10kW SLEEP will be used in all warfare conditions and all phases of peacetime training. Weapons posing a threat to the set include small arms, artillery, missiles, saboteurs, airborne and heliborne units, directed energy systems, unconventional warfare (UW) teams and special purpose forces. The 10kW SLEEP will be exposed to the same threat environment as the typical systems and units it supports.

(2) Operational Environments. The 10kW SLEEP sets will be used in all warfare conditions (including NBC) and all phases of peacetime training. The 10kW SLEEP sets will operate in all climatic conditions, hot, basis, cold, and severe cold as described in Army Regulation (AR) 70-38.

c. Constraints. The aural and thermal IR characteristics of the current generators create an operational signature that is unacceptable for

the generators and the units they support. The current generators no longer meet the mobility and operational requirements for worldwide deployment.

d Operational Concept. Since 10kW SLEEP must produce electric power for command posts; C^3I systems; maintenance and logistics functions; and other support activities where high reliability, mobility and signature suppression are essential, a 10kW SLEEP capability becomes mission essential. The system will be used in high to low intensity conflicts so it must be effective in all anticipated tactical conditions. It must be capable of movement by all strategic and tactical transportation means. It must have a low operational signature to reduce detection and hardened against the threat environment discussed in section b above. It must be multi-fueled, capable of continuous operation; and, have improved RAM-D characteristics. The operator will perform maintenance with a minimum of higher level support.

10kW SLEEP will be supported by the Army's standard logistic system. An Integrated Logistic Support Plan (ILSP) will be developed by the Army and become part of the 10kW SLEEP Program Management Documentation.

e. Specific Functional Objectives.

(1) Improve operational signature.
(2) Improve survivability
(3) Improve RAM-D characteristics
(4) Improve POL characteristics
(5) Improve electrical characteristics.

f. System Alternatives.

(1) Current System. The Army currently uses 10kW, internal combustion gasoline power generators. The current systems have low reliability, require high logistic support, have a high operational signature, cumbersome POL requirements and over one-half have exceeded their design life. These generators hinder successful

mission accomplishment and battlefield survivability.

(2) 10kW SLEEP. The 10kW SLEEP will be designed to overcome the deficiencies of the current 10kW generators. It will be an electrical power plant that can deliver 10 kW of power to US Army tactical units. It will be lightweight, mobile and difficult to detect by aural and thermal (IR) means. It will be highly reliable and have a multi-fuel capability.

g. System Characteristics.

(1) Current System. Previously described in paragraph 3 f., of System Alternatives.

(2) 10 kW SLEEP. The 10kW SLEEP will be capable of providing 10kW of electric power in three modes: 400 Hertz (Hz) alternating current (AC), 60 Hz AC and 28 volts direct current (DC). The volume will be no more than 30 cubic feet. The maximum height is 96 inches and the maximum weight is 650 pounds. The mean time between operational mission failure (MTBOMF) goal is 600 hours. Aural detectability must not be possible from less than 100 meters. The thermal IR signature must not be grater that $\pm$ 4°C from ambient background with 90% exposed surface area. It will have an onboard fuel tank with an 3 hour capability.

h. Costs of Alternative Systems.

(1) Current System. Cost estimates for the current system vary.

(2) 10kW SLEEP. The research and development effort and associated cost estimates for 10kW SLEEP are predicted on the maturity of technologies selected. The estimated costs for Research and Development are estimated at $8,970K for Advanced and Engineering Development efforts. These costs are based on one type and sized of 10kW SLEEP being developed.

Production quantities are projected to be 1,660 units. Production costs are estimated to be approximately $32.6M.

All costs are estimated in FY88 dollars.

The sustainment cost, including fielding, over the total number of operating years is estimated to be approximately $88.7M.

The total life cycle cost of SLEEP is estimated at $130.4M.

i. Uncertainties.

(1) The technical ability to design and configure a system that will not exceed a weight of 650 pounds and a size of 30 cubic feet and meet the operational signature requirements. Exceeding the weight and size requirements adversely impacts on the transportability of the generator.

(2). The technical ability to achieve RAM-D goals within the size and weight requirements. Frequent repairs increase logistical support and reduces system operational availability to the generator. The RAM-D goals must be obtained within the size and weight requirements.

(3). The technical ability to reduce operational aural and thermal IR signatures within the size and weight requirements. A low operational signature reduces system vulnerability and enhances the survivability of the shelter. The operational signatures must be reduced within the size and weight requirements.

(4). The technical ability to harden the system against NBC contamination/decontamination and HAEMP within the size and weight requirements. The battlefield will be subject to these effects so the system must be capable of operating in such an environments.

The system survivability must be achieved within the size and weight requirements.

4. PREFERRED ALTERNATIVES.

Based on this analysis, the 10kW SLEEP is the preferred alternative.

APPENDIX G

SYSTEM CONCEPT PAPER

SYSTEM CONCEPT PAPER

10 KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

10 March 1988

Prepared For:

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SYSTEM CONCEPT PAPER
FOR THE
10 KILOWATT (KW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

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SYSTEM CONCEPT PAPER

10 KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

I. SYSTEM DESCRIPTION.

The 10 Kilowatt Signature Suppressed Lightweight Electric Energy Plant (10kW SLEEP) design specifications require a lightweight tactical generator with very low aural and infrared (IR) detectability. The 10kW SLEEP, with improved reliability and low signatures, will decrease the potential of endangering personnel and equipment, increase a unit's mission performance capability, and reduce the need to operate combat vehicles as an electric power source within critical and sensitive areas.

The 10kW SLEEP must be fully interchangeable in form, fit, and function (F^3) with generator sets of similar power rating. Nuclear capable delivery units and associated combat service support units in the brigade area will receive priority for these generators. The new generator set will be available in three modes: two Alternating Current (AC) modes, Mode II, 400 Hertz (Hz) and Mode III, 60 Hz; and one Direct Current (DC) mode, Mode IV. The Basis of Issue Plan (BOIP) will list quantities, support equipment, personnel changes, and the Quantitative and Qualitative Personnel Requirements Information (QQPRI) will identify operator and maintenance skills. These documents will be developed at a later date.

II. HISTORY.

The Required Operational Capability (ROC), approved in 1975, and the Operational and Organizational Plan, approved in 1985, define the requirements for the 10kW SLEEP. The ROC proposed that an entire family of SLEEP generator sets be developed, with ratings of 0.5kW, 1.5kW, 3kW, 5kW, and 10kW. The ROC also suggested several possible technical approaches to meet the SLEEP requirement.

Management of the 10kW SLEEP procurement is a Government and contractor team effort, with the Department of Defense (DOD) Project Manager, Mobile Electric Power (PM-MEP) having overall program management responsibility. A total contractor managed approach is not appropriate for this equipment because the 10kW SLEEP technology selection and implementation process will require numerous Government decisions and interactions with the contractor team. In addition, equipment development may require several contractors. The US Army Engineer School (USAENS) has been designated as the combat developer and proponent school by the US Army Training and Doctrine Command (TRADOC). Additionally, the US Army Belvoir Research, Development and Engineering Center (BELVOIR) has been designated as the materiel developer by US Army Materiel Command (AMC) and will assist PM-MEP with the program. BELVOIR responsibility includes the research and development actions up to and including equipment Type Classification (TC). After TC, The US Army Troop Support Command (TROSCOM) will have procurement, production, and readiness responsibility for the 10kW SLEEP.

III. MISSION AREA.

A. Role. The primary role of 10kW SLEEP is to provide high reliability, availability, maintainability, and durability (RAM-D); mobility; and signature suppressed power generation essential to mission performance and the survivability of supported units. SLEEP will produce electric power for use by nuclear capable delivery systems; command posts; command, control, communications, and intelligence (C^3I) systems; maintenance and logistics functions; and, other support activities in the brigade area. In addition, the 10kW SLEEP must be operational anywhere that US forces may be deployed including difficult terrain conditions and climatic categories including hot, basic, cold, and severe cold.

B. Operational Need. The 10kW SLEEP must emit no detectable noise at 100 meters. The generator set must also support missions requiring high reliability and low signature. These missions can range up to 360

hours of continuous operation. On a typical 24 hour mission, the 10kW SLEEP with vehicle backup power, will be expected to operate for 21.25 hours; with the remaining time allocated for one move per day of 1.50 hours and five maintenance periods per day of 0.25 hours each. The set must be operated and maintained by appropriately dressed and qualified 5th percentile female through 95th percentile male soldiers including arctic and nuclear, biological, and chemical (NBC) protective clothing at Mission Oriented Protective Posture (MOPP) IV. Health, Safety and Human Factors Engineering (HFE) Military Standards (MIL-STDs) also apply.

IV. THREAT ASSESSMENT.

The survivability of US Army units is eroded by the development and use of threat force's aural and thermal detection and analysis tools. These detection and analysis tools allow threat forces to identify and target specific US units by analyzing the electric power generation equipment signatures. Each type of unit has unique power requirements and therefore, a unique aural and thermal signature. Standard Army electric generators allow long range detection and subsequent analysis due to their large signatures. Development of a generator able to overcome this threat is essential.

In general, the 10kW SLEEP should be as survivable as the systems and units supported. Therefore, the set must be able to meet various types of threats such as weaponry, environmental, and NBC contamination. Specific weapons include those found in the brigade area such as small arms, artillery, missiles, saboteurs, airborne and heliborne units, directed energy systems, unconventional warfare (UW) teams, and special purpose forces. The 10kW SLEEP environmental threats include: extreme cold and heat, high humidity, rain, salt fog, and snow. NBC contamination and decontamination survivability are required and will be enhanced with Chemical Agent Resistant Coating (CARC). Shock conditions, fungus, and high altitude electromagnetic pulse (HAEMP) must also be endured during missions.

V. SHORTFALLS OF EXISTING SYSTEMS.

In addition to the high signatures, the current fleet of standard electric power generators is characterized by heavy gasoline internal combustion engine driven systems, nearly one-half of which have exceeded their design life. These characteristics create supply problems due to non-standard POL requirements, low reliability, and high support asset demands. Current generators also decrease mission efficiency because excessive generator noise leads to the inability to identify threat force intrusions.

VI. ALTERNATIVES CONSIDERED.

Three alternatives have been identified to satisfy the Army's requirement for a signature suppressed electric energy plant. The program, thus far, has focused on identifying a system which would lead to the procurement of SLEEP at the lowest cost, with the shortest schedules, and at the lowest risk to the Government. Two of the three alternatives, a Rotary Diesel engine driven generator and a Phosphoric Acid Fuel Cell have been rejected for the following reasons:

A. The Rotary Diesel engine driven generators do not appear able to meet the existing SLEEP ROC requirements. Meeting the aural, weight, and thermal requirements concurrently presents a most significant challenge to this technology. A noise suppression enclosure would not be able to suppress the thermal and aural signatures within the weight and size constraints of the SLEEP program. The Rotary Diesel engine, while offering benefits in areas such as risks, logistics support, and industry support, would require an extensive development effort to approach the SLEEP requirements.

B. Phosphoric Acid Fuel Cells are still in the experimental stages of development. This technology would require significant development in order to reach the production stage. Further development of this system for the SLEEP program would necessarily incur a high developmental risk.

VII. DESCRIPTION OF SELECTED ALTERNATIVE.

Increased Government interest in alternative power generation sources has created research work on the Stirling Engine. These programs have developed a Stirling Engines useful for many applications including SLEEP. A 10kW Stirling engine offers the primary advantage of being able to meet all the ROC requirements. This section provides a detailed description of the item, defines the operational concept, and discusses affordability, survivability, standardization, readiness, sustainability, and economy of manpower.

A. Detailed Description. The Stirling Engine represents the most mature and closest to production of the technology options able to meet these requirements. Additional advantages include low noise and thermal signatures, high efficiency, potentially lower required maintenance, and multifuel capability.

1. Although design specifications for current prototype Stirling Engine do not include signature suppression, quiet and efficient operation are inherent qualities of this engine. This engine produces low noise levels without a muffler. Testing, although limited, has demonstrated a 10 decibel (dB) noise differential under the worst case scenario: the Stirling at full power and the diesel idling.

2. The low thermal signature of the Stirling engine results from its high efficiency. Increased engine efficiency decreases the engine heat rejected to the atmosphere. Less heat rejection means a lower thermal signature and better fuel consumption.

3. The Stirling engine's high efficiency results partly from external combustion. As a result, the Stirling engine efficiency is essentially load independent. Therefore optimal fuel consumption and thermal signatures will not vary significantly with different load levels.

4. A further inherent advantage of the Stirling engine revolves around a low required maintenance level. Characteristics such as one igniter, no catalytic converter, no particulate traps required for diesel operation, few oil or oil filter changes required, and minimal lubrication requirements provide for lower maintenance costs, high reliability, and long life.

5. The Stirling Engine offers an additional advantage in multifuel capability. Engine testing using various standard fuels resulted in no decrease in engine performance. Modifications are not required to change fuels. In addition, successful multifuel testing of 37 hours exhibited no major hardware failures during starting and operation using gasoline, diesel, and JP-4 fuels.

6. Although the ASE program has been developed around a 60kW engine, by reducing the engine pressure level the same engine could supply 10kW power without modification. This advantage offers the potential to replace a family of generators with one engine, i.e. a 30kW engine could replace a 10kW or a 60kW engine simply by changing the pressure level. However, this scaling ability across power levels requires testing to substantiate this projection.

B. <u>Operational Concept</u>. SLEEP will be issued to a variety of combat, combat support, and combat service support units. The electric energy plant will be assigned a line item number and will be available as a separate item in accordance with the basis of issue of the supported equipment or system.

C. <u>Affordability</u>. The approved Operational and Organizational (O&O) Plan permits a procurement cost range for SLEEP between $400M and $500M. Based on a recent Basic Cost Estimate (BCE) dated 2 December 1987, the total life cycle cost over 12 operating years is estimated at approximately $69.5M in constant FY87 dollars. These estimates justify SLEEP's affordability.

D. <u>Survivability</u>. The 10kW SLEEP set must be survivable anywhere that US forces may be deployed including difficult terrain conditions and

climatic categories of hot, basic, cold, and severe cold. The 10kW SLEEP set will be capable of being internally transported in United States Air Force (USAF) C-130 and C-140 aircraft, externally transported by US Army helicopters, and, when suitably packaged, delivered by low velocity air drop (LVAD) and low altitude parachute extraction (LAPES) from USAF aircraft. NBC contamination and decontamination survivability are required and will be enhanced with Chemical Agent Resistant Coating (CARC). Operators will be capable of performing all tasks necessary to conduct a hasty decontamination within one hour.

E. Standardization. No standardization problems are expected at this time. Other services and allies have shown little interest in the development and acquisition of the 10kW SLEEP sets. However, Australia, Great Britain, Canada, and other NATO forces are pursuing other signature suppressed generators and are closely monitoring the development of US technologies. The exchange of signature suppression data and program information will be coordinated by PM-MEP.

F. Readiness and Sustainability. SLEEP is a highly sustainable electric energy plant contributing significantly to increased readiness when compared to existing generators. The highly simplified maintenance and supply procedures were discussed previously. These improved procedures, together with the fact that SLEEP will be able to operate with suppressed aural and thermal signatures on multifuels, account for improved readiness and sustainability.

G. Economy of Manpower. No additional personnel will be required for operation or maintenance. Start up, during operation maintenance, and shut-down operations will be performed by unit personnel operating the equipment.

VIII. TECHNICAL RISKS OF SELECTED ALTERNATIVE.

The overall 10kW SLEEP program has a medium risk level because of the unproven technology. The Stirling engine technology has been proven in the

laboratory and is in a transition phase. Current prototype engine introduction into the industrial market follows successful laboratory demonstration. The enegine devlopers are currently working to develop a manufacturing base to make the subsequent transition from prototyping to production. The vast majority (estimated 95%) of the manufacturing processes associated with the Stirling engine are standard to prevailing manufacturing technology.

IX. ACQUISITION STRATEGY.

The 10kW SLEEP will be developed and procured through ASAP. This is the best materiel acquisition approach because the commercial market place does not manufacture power equipment meeting the Army's operational requirement. The program structure for the 10kW SLEEP is characterized by technical feasibility testing and evaluation during the Proof of Principle Phase (POP) and technical, user, and preproduction testing during the Development Proveout Phase (DPP). See Enclosure 1 for a milestone schedule of the SLEEP program.

Upon successful testing and a positive Milestone I/II decision, a Cost Plus Fixed Fee (CPFF) engineering development contract will be competitively awarded. Two POP prototype systems of each generator mode from each selected contractor will be solicited. These prototypes will be used for the Technical Feasibility Test and Evaluation (TFT&E).

A total contractor managed approach is not appropriate for this equipment because the SLEEP technology selection and implementation process will require numerous Government decisions and interactions with the contractor team. The contractor, however, is expected to provide standard manufacturer warranty coverage for the end item and its major components or assemblies. Although the breakout of components and spares will be determined at a later date, the contractor may be required to provide the initial provisioning of spare parts for the equipment. This provisioning will probably be competed separately from the end item.

The 10kW SLEEP design will make maximum use of commercially available and military standard components. The 10kW SLEEP program will maintain a design-to-cost approach throughout development.

The overall maintenance support concept and requirements for transportability, packaging, handling, and storage will be built around the programs established for the current 10kW generators. Any new or additional requirements will be addressed as the program develops. New facilities should not be required for this program.

The 10kW SLEEP should not require additional personnel or a new Military Occupational Specialty (MOS). The introduction of SLEEP technology will require special maintenance methods and procedures which may require some new skills. The use of an Additional Skill Identifier (ASI) for generator maintenance personnel will be considered at a later date. Institutional training should be minimal. New Equipment Training (NET) will be required for instructors and key personnel prior to User Testing (UT) and Preproduction Testing (PPT) and to support the initial fielding of the equipment. The BOIP and QQPRI will confirm the personnel and skill training requirements for the program. The specific requirements then will be included in the Integrated Logistics Support Plan (ILSP).

X. KNOWN ISSUES.

There are no known issues at this time.

XI. DECISIONS NEEDED.

a. Approve the System Concept Paper.

b. Approve Stirling Engines as the technological method of production. Listed below are rationale for why the Stirling Engine should be used in the SLEEP program.

- The Stirling engine meets all the SLEEP program requirements including:
  - Low aural and thermal signatures
  - Low weight
  - High efficiency
  - Potential for lower maintenance requirements.
  - Multifuel capability.
- Out of all of the technological alternatives able to meet the SLEEP requirements, Stirling engines are the most mature and closest to production.

ENCLOSURE 1: MILESTONE SCHEDULE

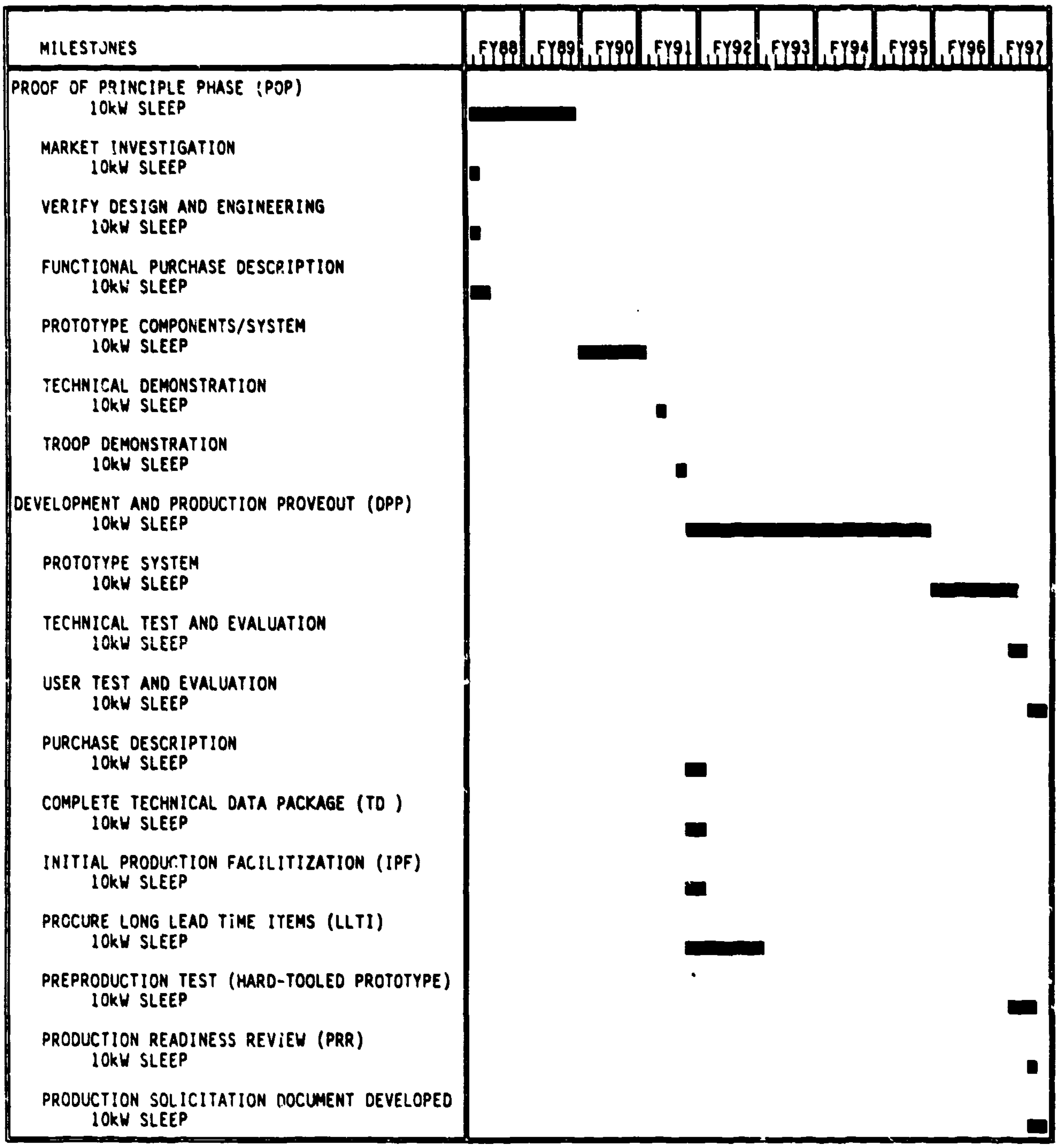
ACTIVITIES AND EVENTS	DURATION ONCE INITIATED
Program Initiation	
Requirements and Technology Base Activity	
Materiel Acquisition Review Board (MARB)	
Proof of Principle Phase (POP)	1-2 Years
Market Investigation	3 Months*
Verify Design and Engineering	3 Months*
Functional Purchase Description (PD)	6 Months*
Prototype Components/System	12 Months
Technical Demonstration	3 Months
Troop Demonstration	3 Months
Milestone Decision Review (MDR) I/II (Go - No Go)	
Development and Production Proveout (DPP)	4 Years
Prototype System	18 Months
Technical Test and Evaluation	6 Months
User Test and Evaluation	6 Months
PD	6 Months*
Complete Technical Data Package (TDP)	6 Months*
Procurement Appropriation (PA) Initiation In-Process Review (IPR)	
Initial Production Facilitization (IPF)	6 Months*
Procure Long Lead Time Items (LLTI)	1 Month *
Preproduction Test (PPT) (Hard-Tooled Prototypes)	6 Months
Production Readiness Review (PRR)	1 Month
Production Solicitation Document Developed	6 Months*
MDR III Type Classification (TC)	
Production and Deployment Phase (PDP)	
Product Acceptance Test	
First Article Test (FAT)	
First Unit Equipped (FUE) (Materiel Release)	
Initial Operational Capability (IOC)	

NOTES:

1. A * indicates events that can be scheduled concurrently during the POP and DPP.
2. The streamlined approach is based on mature technology and low risk, which are confirmed by technical reports, engineering analysis, and/or Market Investigation. MDR I/II will decide on continued research or advancing the program to the next phase.

PROGRAM STRUCTURE
FOR THE
10 KILOWATT (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

FISCAL YEARS



ANNEX A to the SCP-Program Structure

THRESHOLDS
FOR THE
10 KILOWATT (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

	MDR I/III
	10kW SLEEP
COST (CONSTANT FY87 DOLLARS) RDT&E (TOTAL IN THOUSANDS) PROCUREMENT (TOTAL IN THOUS) FLY-AWAY (UNIT) PROCUREMENT (UNIT)	 13,774 30,434 14,691 18,333
SCHEDULED MILESTONE I/III	TBD
PERFORMANCE TECHNICAL EFFICIENCY ELECTRICAL SYSTEM SIZE AND WEIGHT HEALTH AND SAFETY TIE DOWN & HANDLE PROVISIONS CORROSION RESISTANCE RATED CAPACITY FUELS FUEL EFFICIENCY OPERATIONAL AURAL SIGNATURE THERMAL SIGNATURE TRAINING HFE MANPRINT ON-BOARD FUEL OPERATIONAL CLIMATES OPERATING TEMPERATURE RANGE MISSION PROFILE POSITIONING MOBILITY STORAGE AND TRANSPORTATION TRANSPORTABILITY INTERNAL EXTERNAL	 38% @ 820°C 24 VDC, IAW MIL-STD 454 30ft³,wt=650,MIL-STD-1332 MIL-STD-1474, MIL-STD-882 IAW MIL-STD 209, MIL-A- 1472 p. 5.11.1.1 IAW MIL-STD-810 10kW multifueled 50% above 3125lb wt.class non-detectable up to 300M MIL-STD-1472 +/- 4°C from ambient temp IAW PD IAW MIL-STD-1472C IAW PD 4 Hours (12 gallon) Hot,Basic,Cold,SevereCold Air temp (65°F to -50°F) 21.5 hours operating 1.0 hours standby 1.5 hours movement Grades up to 15° 100% with trailer AR 70-38, 160°F to -50°F IAW MIL-A-8421, AFSC, HDBK [illegible]-11,MIL-STD-1366 MIL-HDBK-157 C-130/141 Army helicopter
READINESS/SUPPORTABILITY TECHNICAL NBC CONTAMINATION/DECONTAM- INATION EMI,EMC SAFETY OPERATIONAL RELIABILITY AVAILABILITY MAINTAINABILITY DURABILITY	 IAW AR 70-60, TRADOC Reg 1-4, USANCA IAW MIL-STD 461 Automatic safety controls MTBF 400 HOURS 95% MR = .05 Est. Service life= 12 yrs
INDUSTRIAL BASE LEADTIME TO PRODUCE PRODUCTION BUILDUP RATE PRODUCTION RATE SURGE RATE	TBD

RESOURCES (COST TRACK SUMMARY)
FOR THE
10 KILOWATT (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

(Thousands of Dollars)

	CONSTANT FY88 DOLLARS	ESCALATED FY88 DOLLARS
	10kW SLEEP	10kW SLEEP
DEVELOPMENT PHASE		
DEVELOPMENT ENGINEERING	9517.0	9517.0
DATA	660.0	660.0
SYSTEM TEST & EVALUATION	1511.0	1511.0
SYSTEM/PROJECT MANAGEMENT	2055.0	2055.0
TRAINING, SERVICES & EQUIPMENT	1108.0	1108.0
FACILITIES	0.0	0.0
OTHER RDT&E COSTS	0.0	0.0
TOTAL DEVELOPMENT COSTS	13744.0	13744.0
PRODUCTION PHASE		
PROCUREMENT		
SYSTEM COSTS	26240.5	34879.6
FLYAWAY	24387.5	32416.5
OTHER SYSTEM COSTS	1853.0	2463.1
INITIAL SPARES	4193.1	5573.6
OTHER LINE ITEM PROCUREMENT	0.0	0.0
TOTAL PROCUREMENT APPROPRIATION	30433.7	40453.3
MILCON	0.0	0.0
O&M	687.4	913.7
MILPERS	0.0	0.0
TOTAL PRODUCTION PHASE	31121.1	41367.0
TOTAL OPERATING & SUPPORT PHASE	15650.2	20802.7
TOTAL LIFE-CYCLE REQUIREMENTS	60545.3	80478.5
AVERAGE ANNUAL SYSTEM O&S COSTS	0.8	1.0
# OF SYSTEMS: 1660 # OF YEARS:12		
MILITARY MANPOWER	N/A	N/A
UNIT MANNING		
PROGRAM TOTALS		

ANNEX C to SCP-Resources (cost track summary)

RESOURCES (FUNDING PROFILE)
FOR THE
10 KILOWATT (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

(Thousands of Dollars)

	PREFERRED ALTERNATIVE: 10kW SLEEP						
	FY88	FY89	FY90	FY91	FY92	FY93	TOTAL PROGRAM
DEVELOPMENT PHASE							
DEVELOPMENT ENGINEERING	1432.3	2263.4	1062.8	2395.8	1939.4	423.3	9517.0
DATA	82.5	165.0	82.5	132.0	132.0	66.0	660.0
SYSTEM TEST & EVALUATION	42.0	80.0	462.0	42.0	111.0	774.0	1511.0
SYSTEM/PROJECT MGMT	102.8	102.8	822.0	102.8	102.8	822.0	2055.0
TRAINING, SERVICES & EQUIPMENT	138.5	277.0	138.5	221.6	221.6	110.8	1108.0
FACILITIES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER RDT&E DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL DEVELOPMENT PHASE	1827.7	2879.8	2177.4	2960.6	2452.2	1476.4	13774.0
PRODUCTION PHASE							
PROCUREMENT							
SYSTEM COST							26210.5
FLYAWAY							24387.5
OTHER SYSTEM COSTS							1823.0
LONG LEAD REQUIREMENTS							0.0
INITIAL SPARES							4193.1
OTHER LINE ITEM PROCUREMENT							0.0
TOTAL PROCUREMENT APPROPRIATION							30433.7
CURRENT APPROVED FYDP, PROCUREMENT							138320.1
MILCON							0.0
O&M							687.4
MILPERS							0.0
TOTAL PRODUCTION PHASE							31121.1
OPERATING AND SUPPORT PHASE							14537.0
MILPERS							1113.2
O&M							8832.4
PROCUREMENT							5704.6
TOTAL OPERATING AND SUPPORT PHASE							15650.2
OTHER FUNDING							
DURING DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DURING PRODUCTION	TBD	TBD	TBD	TBD	TBD	TBD	TBD
INDUSTRIAL CAPACITY INVESTMENT	TBD	TBD	TBD	TBD	TBD	TBD	TBD
TOTAL "OTHER" COSTS	TBD	TBD	TBD	TBD	TBD	TBD	TBD
TOTAL LIFE-CYCLE REQUIREMENTS							60545.3

ANNEX D to SCP-Resources (funding profile)

SUMMARY OF LIFE-CYCLE COSTS OF ALTERNATIVES
FOR THE
10 KILOWATT (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT
ELECTRIC ENERGY PLANT
(10kW SLEEP)

CONSTANT FY88 DOLLARS (IN THOUSANDS)

ALTERNATIVE	DEVELOPMENT	PRODUCTION (MOST LIKELY)	OPERATING AND SUPPORT (MOST LIKELY)	TOTAL (MOST LIKELY)
STANDARD DIESEL ENGINE GENERATOR	4,871	10,837	27,342	43,050
PHOSPHORIC ACID FUEL CELLS	TBD	TBD	TBD	TBD

ESCALATED DOLLARS (IN THOUSANDS)

ALTERNATIVE	DEVELOPMENT	PRODUCTION (MOST LIKELY)	OPERATING AND SUPPORT (MOST LIKELY)	TOTAL (MOST LIKELY)
STANDARD DIESEL ENGINE GENERATOR	6,475	14,405	36,344	57,244
PHOSPHORIC ACID FUEL CELLS	TBD	TBD	TBD	TBD

TBD - Phosphoric Acid Fuel Cells are still in the experimental stage of development. Therefore no cost analysis can be conducted at this time. However, it can be estimated that the development costs would be higher than the Stirling and Diesel engines, the production costs would be close to that of the diesel engines and the operating and support costs would most likely be much lower than any of the alternatives.

ANNEX E to the SCP-Summary of life-cycle costs of alternatives.

APPENDIX H

TEST AND EVALUATION MASTER PLAN

TEST AND EVALUATION MASTER PLAN

10 KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

23 February 1988

Prepared for:

US ARMY
BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

TEST AND EVALUATION MASTER PLAN (TEMP)

FOR

10 KILOWATT SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS
(10KW SLEEP)

PROJECT TASK NUMBER:	CARDS REFERENCE NUMBER: 0652
REQUIREMENT DOCUMENT:	REQUIRED OPERATIONAL CAPABILITY (ROC) FOR SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS (SLEEP), US ARMY TRAINING AND DOCTRINE COMMAND (TRADOC) ACN 13215, APPROVED: 4 JUNE 1975. REVISED REQUIRED OPERATIONAL CAPABILITY (ROC) FOR SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS (SLEEP), TRADOC ACN 13215, DRAFT: 10 JANUARY 1984.
STATUS OF TEMP:	DRAFT FOR CONCURRENCE
DATE OF TEMP:	23 February 1988
TEMP PREPARED BY:	LOGISTICS SUPPORT DIRECTORATE US ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER POWER GENERATION DIVISION (STRBE-FG) FORT BELVOIR, VIRGINIA 22060-5606
RELEASE LIMITATIONS:	US GOVERNMENT AGENCIES ONLY

SECURITY
CLASSIFICATION: UNCLASSIFIED

TEST AND EVALUATION MASTER PLAN (TEMP)
CONCURRENCE RECORD FOR
10 KILOWATT SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS
(10KW SLEEP)

PRINCIPAL MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE SIGNATURE	DATE
1. MATERIEL DEVELOPER AND TECHNICAL DEMONSTRATION CONDUCTOR	US ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER ATTN: STRBE-FG Fort Belvoir, Virginia 22060-5606	________	____
2. COMBAT DEVELOPER, TROOP DEMONSTRATION CONDUCTOR, USER REPRESENTATIVE, AND TRAINER	US ARMY ENGINEER SCHOOL ATTN:	________	____
3. USER TESTER, PREPRODUCTION TESTER, AND PRODUCT ACCEPTANCE TESTER	US ARMY OPERATIONAL TEST AND EVALUATION ACTIVITY ATTN:	________	____
4. TROOP DEMONSTRATION CONDUCTOR, USER TEST EVALUATOR, PREPRODUCTION TEST EVALUATOR,	COMMANDER US ARMY COMBINED ARMS CENTER ATTN: ATZL-TIE	________	____
5. TECHNICAL TEST TESTER AND EVALUATOR, TECHNICAL DEMONSTRATION EVALUATOR, AND PRODUCT ACCEPTANCE TESTER	COMMANDER US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTS-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005	________	____

PRINCIPAL MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE SIGNATURE	DATE
6. LOGISTICIAN	COMMANDANT US ARMY LOGISTICS EVALUATION AGENCY ATTN: DALO-LEA New Cumberland, PA 17070		

TEST AND EVALUATION MASTER PLAN
FOR
10 KILOWATT SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS
(10KW SLEEP)

TEST AND EVALUATION MASTER PLAN (TEMP)
FOR
10 KILOWATT SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS
(10KW SLEEP)

PART I - DESCRIPTION

1. MISSION OF SYSTEM

a. Background. Battlefield projections for the next decade and beyond, forecast land operations being conducted under intense combat which could include nuclear, biological, and chemical (NBC) warfare. Consequently, the Army's forces are being modernized with advanced technology equipment to effectively counter potential enemies across this new integrated battlefield.

The Army uses advanced technology in order to fulfill its basic mission, meet and defeat enemy land forces. Areas where this technology is employed include: automated data processing; combat service support (CSS); command control, communication, and intelligence (C^3I); computers; detection and sensing equipment; fire control data collection; maintenance; medical support; radar systems; target acquisition; and weapons systems. This modern equipment is essential in the conduct of the mission and requires quiet, reliable, low visibility generator support; however, the Army's electrical support capabilities have not kept pace.

The existing generator sets were standardized in the early 1970s, and represent aged technology and conservative engine and generator design. There have been repeated complaints from units employing generators that the acoustic and thermal infrared (IR) signatures are too "loud" and too "hot." Improvements by threat forces in aural and IR detection sensor technology place units operating these generator sets in increased risk of detection. Advanced signature analysis can accurately predict the function, echelon of deployment, and relative importance of tactical units operating these generators. Furthermore, the high aural signatures can mask the sounds of approaching enemy forces and disrupt operator concentration.

b. Need. Electric energy plants which are difficult to detect by aural and thermal IR means, highly reliable, mobile, compact, easily transported, and multi-fueled are required to furnish electrical energy for C^3I equipment, detectors and sensors, ground surveillance radar, selected CSS equipment, visual and thermal IR illumination devices, and other systems where low battlefield signatures are required for mission accomplishment and survivability.

c. Mission. The 10kW SLEEP sets will supply electrical power of acceptable quality and output for units requiring highly reliable generators which exhibit low battlefield signatures for mission accomplishment and

survivability. The new 10kW sets will be fully interchangeable with the current 10kW power generating equipment of the same mode and will he used in all warfare conditions (including NBC) and all phases of peacetime training. The 10kW SLEEP sets will operate in all climatic conditions, hot, basic, cold, and severe cold as described in Army Regulation (AR) 70-38; the sets may employ winterization kits for severe cold conditions. The new generators will be fully transportable by strategic and tactical transportation modes: air, marine, rail, and highway (i.e., towing of trailer mounted configurations by designated prime movers; external air transport by US Army light or medium rotary wing aircraft; internal air transport by C-130 and larger US Air Force aircraft; and delivery by low velocity air drop (LVAD) and low altitude parachute extraction (LAPE).

A minimum of new special tools and equipment and no new facilities will be required to support the 10kW SLEEP generator sets. These generators will be supported through the Department of Defense (DOD) Logistical System and the standard Army three-level maintenance concept. The sets will be operable by personnel wearing cold weather and Mission Oriented Protective Posture (MOPP) IV gear. The logistical supportability of the 10kW SLEEP generator sets will be demonstrated prior to system acceptance.

2. SYSTEM DESCRIPTION

The 10kW SLEEP will reduce the vulnerability of the units and equipment they support by having a battlefield signature which is far below the current standard mobile electric power (MEP) systems. The 10kW SLEEP systems will incorporate high altitude electromagnetic pulse (HAEMP) hardened and NBC contamination/decontamination survivable. In order to ease logistical support requirements, the new systems shall be multi-fueled and will incorporate technologies which improve system reliability, interchangeability, survivability in environmental extremes, maintainability, supportability, safety, weight, size, and transportability. The 10kW SLEEP will make maximum use of commercially available parts and standard manufacturing processes and systems. The performance requirements of the 10kW SLEEP generator sets are fully described in functional Purchase Description (PD) for the Signature Suppressed, Lightweight Electric Energy Plant dated 7 November 1987.

a. Key Functions. Compared with the current 10kW generator sets, the 10kW SLEEP sets will have lower the aural and IR signatures and improved reliability. The Type I (tactical), Class 2 (utility) sets will be designed in three modes (Mode II - 400 Hertz (Hz), Mode III - 60 Hz, and Mode IV- Direct Current (DC)). These new generators will use standard military coolants, lubricants, and fuels.

b. Interfaces. The key programmatic and hardware interfaces for the new 10kW SLEEP generator sets are:

(1) The family of power distribution wiring sets, Distribution Illumination Systems, Electrical (DISE). DISE equipment will be used to distribute power from one source to a number of users through circuit protected links. This equipment has been type classified.

(2) The US Army Belvoir Research, Development and Engineering Center (BELVOIR), began an IR camouflage net program July 1984. This program is currently an in-house, internally funded program. The camouflage nets will provide the generators with protection from visual sighting and may augment its IR suppression capabilities, and thereby, permit surpassing of the Army's battlefield signature requirement.

(3) Australia, Great Britain, Canada, and other North Atlantic Treaty Organization (NATO) forces have expressed some interest in pursuing signature suppressed generator sets. These countries are closely monitoring developing US signature suppression technologies.

c. Unique Characteristics. The 10kW SLEEP tactical generator sets will have suppressed aural and IR battlefield signatures; NBC contamination and decontamination survivability; and HAEMP hardening. There are no other unique characteristics designated for the 10kW SLEEP which could lead to special test requirements.

3. REQUIRED OPERATIONAL CHARACTERISTICS

The required operational characteristics of the 10kW SLEEP are derived from the approved Required Operational Capability (ROC) for a family of Silent Lightweight Electric Energy Plants (SLEEP), dated 4 June 1975, the draft revision to the ROC, dated 10 January 1984, and the draft PD for the Signature Suppressed, Lightweight Electric Energy Plant dated 7 November 1987, are described below. Modifications to these characteristics will be made according to any changes contained in the approved ROC and approved PD. Those characteristics identified by an asterisk are considered to be critical to the ability of the 10kW SLEEP to accomplish intended operational missions.

* a. Surface Temperature. The temperature 90% of the surface of the 10kW SLEEP will differ by no more than 4°C from the ambient air temperature.

* b. Aural Signature. The 10kW SLEEP will meet the aural nondetectability limits of Table 3 of Military Standard (MIL-STD)-1474 at a nominal nondetectability distance of 100-300 meters when operating at all possible loads; from no load to rated load and at any attainable frequency. The 10kW SLEEP must have an aural signature that does not exceed 45 dBA at 7 meters from the perimeter of the set. Also, the noise from the set shall not exceed 85 dBA at the operator's station, which is 0.7 meter from the control panel, while the doors are open.

* c. Electric Power. The 10kW SLEEP must be capable of providing electric power suitable to support tactical systems and equipment in all specified environmental conditions. The generator sets must provide quality and type electric power in accordance with (IAW) MIL-STD-1332, Table II, for Utility Classes 2B and 2C.

* d. Positioning. The 10kW SLEEP must be operable when situated in any direction on uneven terrain with grades up to 15°.

* e. Malfunction Protection. The 10kW SLEEP must be inherently protected against destructive malfunctions and have a manual override.

* f. Fluid Indicators. All 10kW SLEEP must have indicators for fuel, lubricants and coolants. These indicators shall be verified for their accuracy.

* g. Preventive Maintenance Check and Service (PMCS) Items. Critical PMCS items for the generator sets must be designated for identification and easily accessible.

* h. Operational Performance. The 10kW SLEEP must be capable of performing operations in climatic conditions of hot, basic, cold, and extreme cold as described in AR 70-38. All 10kW SLEEP will be fully operable at rated load at sea level; be fully operable at rated load at 107°F and 3,000 feet; operable at 90% of rated load at 107°F and 5,000 feet; and operable at 75% of rated load at 95°F and 8,000 feet. The 10kW SLEEP must be capable of being stored in, and undamaged by, severe cold through extreme hot temperatures (-60°F to +160°F).

* i. Substitutability. The 10kW SLEEP end item must be capable of substitution with present DOD standard generator sets of comparable power output and/or MIL-STD trailer size.

* j. System Supportability. The 10kW SLEEP must be supportable by the current logistics organizations, doctrine, and procedures. Standard fuels, lubricants, and repair tools will be used, where applicable, to minimize the number of redundant new line items. To reduce the maintenance requirements, the 10kW SLEEP will be equipped with a standard diagnosis connector assembly (DCA) and supportable standard Army tools, test, maintenance, and diagnostic equipment (TMDE), and Simplified Test Equipment-Internal Combustion Engine (STE-ICE). Where possible, the required TMDE will be selected from the TMDE Preferred Items List (Department of the Army (DA) Pamphlet No. 700-21-1). The 10kW SLEEP will not require special tools or support equipment. The technical manuals, publications, and other training documentation for the 10kW SLEEP must be in compliance with Military Standard MIL-M-7298C Manual, Technical Commercial Equipment.

* k. NBC Contamination/Decontamination Survivability. The 10kW SLEEP systems must be NBC contamination and decontamination survivable and have Chemical Agent Resistant Coating (CARC). The equipment must have the capabilities to be decontaminated and withstand damaging effects of decontamination agents and procedures. The systems must be operable and maintainable by personnel wearing full NBC protective garments (MOPP IV).

* l. Human Factors Engineering. The generator sets shall be designed IAW accepted criteria for Human Factors Engineering as described in MIL-STD-1472C. The 10kW SLEEP will be operable and maintainable by 5th through 95th percentile soldiers who are dressed appropriately for the environment (climatic types of hot, basic, cold, and extreme cold as defined in AR 70-38, to include NBC conditions).

* m. Health and Safety. The operations of the 10kW SLEEP will not expose personnel to undue health or safety risks. Areas of special concern are: burred, hot, and sharp surfaces or edges; electrical equipment and connections; exposed moving parts; fuel system leaks; noise; operation under limited visibility conditions; and transportation safety. The 10kW SLEEP shall meet the provisions of MIL-STD-882, MIL-STD-1472C 5.13, and MIL-STD-454 Requirement 1.

* n. Transportability. The 10kW SLEEP must be capable of both inter- and intra- theater deployment by air, marine, highway, and rail. The generator set(s) must be towable in trailer mounted configurations by designated prime movers, externally air transportable by Army light or medium rotary wing aircraft, internally by C-130 and larger Air Force aircraft, and air deliverable by LVAD and LAPE.

* o. Compatibility With Prime Mover. The 10kW SLEEP towed generator sets must be compatible with the Commercial Utility Cargo Vehicle (CUCV), High Mobility Multipurpose Wheeled Vehicle (HMMWV), 2 and 1/2 Ton Truck, and 5 Ton Truck and specified trailers. Each generator set must be capable of using the same standard military fuels, lubricants, and coolants as their designated prime mover.

* p. Starting. Without aids, the 10kW SLEEP will start within 5 minutes at each of the following conditions or any possible combination of the following conditions:

(1) With ambient temperatures from +120°F to -25°F at sea level and all possible relative humidity.
(2) At any altitude up to 5,000 feet above sea level at an ambient temperature of 107°F.
(3) With the base of the set in planes from level to 15 degrees from level.
(4) With 4 ± 1 inches of rain per hour impinging on the generator from vertical up to 45° from vertical.
(5) With up to 355 British Thermal Units (BTUs) per square foot per hour of solar radiation.
(6) At sand/dust particle concentrations of 1400 mg per cubic meter.
(7) With a snow fall rate of up to 2 inches per hour for 12 hours.
(8) With a steady wind speed of 73 feet per second and gust up to 95 feet per second at a height of up to 10 feet above ground level.
(9) In a fog or sea spray environment.
(10) Start at temperatures from -25°F to -50°F after a pre-planned product improvement adds integral electric or fuel burning winterization kits.

* q. Manpower and Personnel Integration (MANPRINT). The 10kW SLEEP must be MANPRINT compatible by complying with the provisions of AR 602-2. The generator sets will not require additional manpower (i.e., the equipment will be operated and maintained by the same personnel with the same skills now operating and maintaining existing DOD standard generator sets). Train-

ing considerations will include new equipment training (NET), to train the initial instructor base; the use of service schools and training centers to provide the appropriate training to 10kW SLEEP support personnel; and documentation for training and maintenance.

* r. Reliability, Availability, Maintainability, and Durability (RAM-D). The 10kW SLEEP must have RAM-D objectives that satisfy electric power mission requirements. The generator sets shall have a mean time between operational mission failure (MTBOMF) which has a minimum acceptable value (MAV) of 400 hours and best operational capability (BOC) of 600 hours. The maintenance ratio for the 10kW SLEEP sets shall not to exceed 0.05. The minimum life of the 10kW SLEEP shall exceed 12,000 hours with generator overhaul at intervals not less than 6,000 hours and engine overhaul allowed at no less than 3,000 hour intervals. The 10kW SLEEP shall have an operational availability of at least 0.95. The minimum interval between scheduled PMCS shall be 12 hours. Scheduled maintenance service will be no more frequent that 250 hours. The 10kW SLEEP must be capable of having one person change the oil during scheduled services within 20 minutes. The system will provide a means to easily check and add oil while the system is running.

4. REQUIRED TECHNICAL CHARACTERISTICS

The required technical characteristics of the 10kW SLEEP are derived from the approved ROC for a family of SLEEP, dated 4 June 1975, the draft revision to the ROC, dated 10 January 1984, and the draft PD for the Signature Suppressed, Lightweight Electric Energy Plant dated 7 November 1987, and are described below. Modifications to these characteristics will be made according to any changes contained in the approved ROC and approved PD. Those characteristics identified by an asterisk are considered to be critical to the ability of the 10kW SLEEP to accomplish intended missions.

* a. Construction. 10kW SLEEP must be durable and constructed to withstand the effects of delivery by LVAD and LAPE; exposure to the elements; highway travel at convoy speeds, marine, and air transport; and rough terrain mobility. The housing of the sets shall be removable and protect the interior from wind driven rain, sleet, and snow. The set housing will be constructed with doors to allow access portions of the set which require routine maintenance. The systems will be fabricated using materials which are compatible and either inherently corrosion resistant or protected against corrosion and deterioration. Dissimilar metals shall not be used in intimate contact unless suitably protected (insulated) to counter electrolytic corrosion per MIL-STD-889.

* b. Maintenance. 10kW SLEEP will provide the necessary devices to monitor operating conditions and indicate circumstances which may cause shutdowns and malfunctions. The 10kW SLEEP will be equipped with a method/device for bleeding the fuel system of air/water during pre-, post-, or in operation checks. The sets will also provide an oil sampling valve. The sets will have solderless connections.

* c. Voltage and Frequency Adjustment.

(1) 60 Hz or 400 Hz Generator Sets. The generator sets will permit the operator to adjust the voltage over a range which includes -5 to +10 percent of rated voltage. By means of a frequency adjustment device, it shall be possible to adjust the frequency when operated at any constant load; the minimum adjustment range shall be +3 percent of rated frequency. Frequency adjustments will not trigger the overspeed protective device. Refer to section 3.9 of the PD for 60 Hz and 400 Hz frequency and voltage adjustment specifications.

(2) DC Generator Sets. The generator sets will permit the operator to adjust the voltage over a range which includes 23 to 35 volts at normal operating temperatures and ±5 percent of rated voltage at extreme temperatures. By means of a frequency adjustment device, it shall be possible to adjust the frequency when operated at any constant load; the minimum adjustment range shall be +3 percent of rated frequency. Frequency adjustments will not trigger the overspeed protective device. Refer to section 3.10 of the PD for DC frequency and voltage adjustment specifications.

* d. Lift and Tie Down Provisions. The lift and tie down provisions of the 10kW SLEEP will be IAW MIL-STD-209 and MIL-A-8421.

* e. Nuclear, Biological, and Chemical Survivability. The 10kW SLEEP are mission essential; therefore, they must survive NBC contamination and decontamination and shall withstand the effects of the HAEMP nuclear environment. The sets shall have CARC to resist the penetration and absorption of NBC agents and the chemicals and cleaning agents used for decontamination. The design of the sets will ensure there are no cracks, crevices, corners, or hidden surfaces where fluids or NBC agents could accumulate.

* f. Physical Configurations. The maximum size shall be 30 cubic feet and the maximum weight shall be 650 pounds.

* g. Interfaces. The generator sets will be compatible with DISE.

* h. On-board Fuel. The generator sets will include an on-board fuel tank, with auxiliary fuel capability, capable of supporting 12 continuous hours of operation at mission load.

* i. Non-Interference and Susceptibility. The 10kW SLEEP will not emit electromagnetic interference (EMI) and shall not exceed the UM04 limits for class C2 equipment IAW MIL-STD-461. The sets shall meet the radio interference limits for engine generator sets as specified in notice 4 of MIL-STD-461.

* j. Cranking/Starting. The set shall have a 24-volt (nominal) cranking system for starting and control power as described in the PD. The cranking system consists of a cranking motor; start solenoid; batteries; battery retainer; slave receptacle; battery charging system; and sufficient relays, connectors, switches and cable to make a complete system. The system shall have a negative ground. After starting, the set shall be capable

of operating with batteries removed. The generator sets will provide a cranking and battery charging system and capability for slave starting using a standard NATO receptacle conforming to MS52131. The receptacle with cover shall be mounted in a mechanically protected position on the engine end of the set, and shall be connected in parallel with batteries. The 10kW SLEEP will be capable of supporting short duration overload conditions IAW MIL-STD-1332.

* k. Chassis and Trailers. The 10kW SLEEP will be compatible with MIL-STD chassis/trailers or interoperable commercial chassis/trailers to meet the transportability requirement. The 10kW SLEEP chassis and trailer compatibility will correspond to the current 10kW generators of the same mode. The designated trailers are listed below:

MODE	NUMBER OF SETS	TRAILER
10kW 60 Hz	1	3/4-ton modified M101A1 cargo trailer drawing number 97403-13214E1489 (PU332)
	2	1-1/2-ton modified M103A3 trailer chassis drawing number 97403-13216E7430 (PU619)
	1	3/4-ton modified M116A1 trailer chassis drawing number 97403-13221E7325 (PU753)
	2	1-1/2-ton modified M103A3 trailer chassis drawing number 97403-13216E7430 (AN/MJQ 18)
10kW 400 Hz	1	3/4-ton modified M101A1 cargo trailer drawing number 97403-13214E1489 (PU375)
	2	1-1/2-ton modified M103A3 trailer chassis drawing number 97403-13216E7430 (PU656)
10kW DC	To be determined (TBD).	

* l. Carrying Capacity. The 10kW SLEEP will have mountings capable of carrying up to 400 pounds of ancillary and/or safety equipment.

* m. Drains. The 10kW SLEEP units will provide oil and coolant drains readily accessible for servicing.

* n. Transportability. The 10kW SLEEP generator sets will be capable of full tactical and strategic mobility to include cross-country and highway travel and rail, marine, and air transport.

(1) Normal railroad transportation shall be interpreted to mean impact speeds of 10 miles per hour (mph) or less under test conditions specified in MIL-STD-705, method 740.5.

(2) Normal truck or trailer transportation is defined as the conditions experienced during four cycles of a road test with the sets mounted on the trailers specified above. Each cycle shall consist of the

following:

ROAD CONDITIONS	DISTANCE (MILES)	SPEED (MPH)
Paved Highway	250	up to 50
Level Cross-country	250	up to 20
Hilly Cross-country	125	up to 20
Belgian Block	15	up to 20

(3) The sets shall meet the air transportability requirements of MIL-STD-8421 at altitudes up to 50,000 feet IAW the PD. Normal aircraft and helicopter transport shall be interpreted as a 12 inch end-drop under test conditions specified in MIL-STD-705, method 740.3.

* p. Fuels and Lubricants. The 10kW SLEEP systems will operate on all DOD logistical fuels (primarily diesel) to include: turbine fuel (JP-4) conforming to MIL-T-83133, referee grade diesel fuel conforming to MIL-F-46162, or diesel fuels (DF-1, DF-2, or DF-A) conforming to VV-F-800 while meeting all requirements of the 10kW SLEEP PD. Fuel consumption shall not exceed 0.09 gallons per kilowatt hour. Lubricants shall conform to MIL-L-2104 and MIL-L-46167.

* q. Maximum Power. The MAV for maximum power of the 10kW SLEEP sets will be 110 percent of the rated load under all operating conditions specified in the PD.

5. CRITICAL TEST AND EVALUATION ISSUES AND CRITERIA

a. Technical Issues. At this time an Independent Evaluation Plan (IEP) has not been developed, therefore, the following are draft critical technical issues and associated criteria which must be addressed by testing.

T(1). Acceptability of Physical Characteristics.

(a) Compatible materials. Sets shall be fabricated from compatible metals and materials that are inherently corrosion resistant or are treated to inhibit various forms of corrosion and deterioration that may be encountered in the specified storage and operating environment. Design will ensure that dissimilar metals, which produce corrosion, are adequately separated or properly insulated.

(b) Durability. The sets shall not be damaged during normal operations in the specified environments or by rough handling which could be encountered during rail, truck, aircraft, and helicopter transportation and delivery by LVAD and LAPE.

(c) NBC Design. The 10kW SLEEP must be designed and fabricated to avoid cracks, crevices, corners, and hidden surfaces, that would trap and hold contaminants and decontaminants.

(d) Decontamination Survivability. Components and materials shall not be damaged by exposure to steam, water decontaminant solution, or super tropical bleach (STB) when used for decontamination. The 10kW SLEEP will be capable of withstanding five successive decontamination cycles.

(e) Resist Environmental Effects. Materials and coatings for the 10kW SLEEP must be resistant to deterioration and corrosion, to include problems associated with such adverse conditions as humidity, salt fog, fungus, rain, snow, and NBC operations.

(f) Drainage. Drain holes will be provided to avert the accumulation of water or other unwanted fluids.

(g) HAEMP. The sets must survive the effects of HAEMP.

(h) Weight and Size. The 10kW SLEEP weight shall not exceed 650 pounds and the size shall not exceed 30 cubic feet.

(i) Fuel Capacity. The sets will include an on-board fuel capacity capable of supporting 12 continuous hours of operations at mission load.

T(2). Acceptability of Performance Characteristics.

(a) DISE. The 10kW SLEEP will be compatible with DISE.

(b) Overloads. The 10kW SLEEP will support short duration overloads IAW MIL-STD-1332. The generator sets will be providing the operating power to systems, such as air conditioners, which require an excessive amount of voltage/amps to start motors.

(c) Non-Interference. The 10kW SLEEP will not interfere with operationally essential equipment (low EMI signals). The 10kW SLEEP will meet the requirements of MIL-STD-461.

(d) Starting. The 10kW SLEEP will have a cranking and battery charging system and slave starting capability. The sets will provide a cranking and battery charging system capable of slave starting using a standard NATO receptacle.

(e) Voltage and Frequency Regulation. The generators will have a knobs on the control panel to regulate the output voltage and frequency. It is required that the voltage be increased through a clockwise rotation of the knob.

T(3). Logistics Support.

(a) Impact. Assess impact of 10kW SLEEP on the Army's logistical support structure, with emphasis on facilities, personnel capabilities, and Class IX inventory.

(b) Maintenance. Generator design and construction should permit routine service and maintenance by the operator under battlefield conditions (to include personnel in MOPP IV garments).

(c) Tools. Maximum use made of standard tools in the General Mechanic's Automotive Tool Kit (SC 5180-90-CL-N26-HR; National Stock Number (NSN) 5180-00-177-7033; Line Item Number (LIN) W33004).

T(4). Safety.

(a) Mechanical Components and Moving Parts. The evaluation of safety will examine the generator's electrical and mechanical components to verify appropriate personnel protection is employed. Areas of major concern are: electrical insulation, elimination of burred or sharp edges, excessive vibration, excessive noise, explosion, exposed high temperature surfaces, fire, interface with NBC protection equipment, and toxic fumes.

(b) User Interface. The sets shall meet the provisions of MIL-STD-882, MIL-STD-1472C 5.13 and MIL-STD-454 Requirement 1.

(c) Lighting. The sets shall use secure (blue/green) lighting for operations under conditions of darkness.

T(5). <u>Transportation</u>.

(a) Mobility. Full strategic and tactical mobility by air, marine, rail, and highway are essential to mission accomplishment for the 10kW SLEEP.

(b) Slinging, Lift, and Tie Down. Each lift attachment will be capable of carrying a minimum of four times the dry weight of the sets; tie downs will adhere to MIL-A-8421. These tests will also rate the lift and tie down procedures. The slinging, lift and tie down provisions shall be IAW MIL-STD-209.

(c) Towing. Trailer mounted 10kW SLEEP configurations are to be towable by their designated prime mover.

b. <u>Operational Issues</u>. The following summarizes the critical operational issues and associated criteria which must be addressed by testing:

O(1). <u>Compatibility With Designated Prime Movers</u>.

(a) Towing. Able to be trailer mounted and towed by the designated prime movers specified in paragraph 3.a., above.

(b) Fuels, Lubricants, and Coolants. Able to start and operate using the same standard military fuels, lubricants, and coolants as their designated prime movers.

O(2). <u>Acceptability of Battlefield Signature</u>. Comply with the aural nondetectability limits of Table 3 of MIL-STD-1474 at a nominal nondetectability distance of 100-300 meters when operating at all possible loads; from no load to rated load and at any attainable frequency and the requirements for an aural signature that will not exceed 70 dBA at 7 meters from the set and 85 dBA at the operator's station.

O(3). <u>Suitability of Electric Power</u>. Provide electric power IAW MIL-STD-1332 requirements for steady-state and transient voltage and frequency performance.

O(4). <u>Acceptability of Operational Effectiveness Characteristics</u>.

(a) Performance. Ability to operate in hot, basic, cold, and extreme cold climatic conditions as described in AR 70-38 and provide the rated loads at the temperatures and altitudes specified in paragraph 3, above.

(b) Positioning. Ability to be operable when situated in any direction on uneven terrain with grades up to 15°.

(c) Malfunction Protection. Ability to comply with the requirement for protection against destructive malfunctions and have a manual override.

(d) Fluid Indicators. Ability to comply with the requirement for accurate fuel, lubricant, and coolant indicators.

(e) Substitutability. Ability to be substituted for present DOD standard generator sets of comparable power output and/or MIL-STD trailer size.

(f) Transportability. Ability to comply with the requirements specified in paragraph 3, above.

(g) Starting. Ability to comply with the requirements and conditions specified in paragraph 3, above.

0(5). <u>Acceptability of System Supportability Characteristics</u>.

(a) Logistic Support. Ability to be supported by current Army organizations, doctrine, and procedures.

(b) Tools and Test Equipment. Ability to use standard tools, TMDE, and STE-ICE. To assist equipment testing, the generator sets will be equipped with a standard diagnosis connector assembly.

(c) Manuals and Training Documentation. Adequacy of technical manuals and training documentation.

0(6). <u>Acceptability of the NBC Decontamination Survivability Characteristics</u>.

(a) Survivability. Ability to be decontaminated and operated and maintained by personnel wearing full NBC protective garments.

(b) Protective Painting. The 10kW SLEEP end item will be CARC painted.

0(7). <u>Acceptability of Human Factors Engineering and Health and Safety Characteristics</u>.

(a) Human Factors Engineering. Ability to comply with the human factors requirements contained in the draft ROC and MIL-STD-1472C.

(b) Health and Safety. Ability to be operated and maintained by personnel without uncontrolled health or safety hazards.

0(8). <u>Acceptability of MANPRINT Characteristics</u>.

(a) Manpower. Ability to operate and maintain the 10kW SLEEP with the same personnel and same skills now operating and maintaining existing DOD standard generator sets.

(b) Training. Adequacy of NET developed for the 10kW SLEEP program, to include system training and maintenance documents.

0(9). <u>Acceptability of Demonstrated RAM-D Characteristics</u>.

(a) Reliability. Ability to comply with the requirement for a mean-time-between-failure (MTBF) of 600 hours.

(b) Availability. Ability to comply with the requirement for an operational availability of not less than 95 percent.

(c) Maintainability. Ability to demonstrate a maintenance ratio of not less than 0.05, all generator sets will have identifiable PMCS items that are easily accessible, scheduled PMCS shall be no less than 12 hours, scheduled maintenance service shall be no more frequent than 175 hours, and will have the capability to permit one person or crew to change the oil in 20 minutes.

(d) Durability. The 10kW SLEEP sets will be able to operate without critical failure for 3,000 hours and have a minimum life of no less than 12,000 hours.

PART II - PROGRAM SUMMARY

1. MANAGEMENT

a. Program Outline. The 10kW SLEEP generator set development and procurement program will be managed as a Government and contractor team effort. The Project Manager, Mobile Electric Power (PM-MEP), US Army Troop Support Command (TROSCOM), will have overall program management responsibility. BELVOIR has been designated as the materiel developer by the US Army Materiel Command (AMC) and will assist PM-MEP with the program. BELVOIR will be responsible for the research and development (R&D) actions up to and including equipment type classification (TC). After TC, responsibility will be shifted to TROSCOM for procurement, production, and readiness of the 10kW SLEEP generator sets. The US Army Engineer School (USAENS) has been designated as the combat developer and proponent school by the US Army Training and Doctrine Command (TRADOC). A total contractor managed approach is not appropriate for this power equipment because this program is very early in the development process; signature suppression technology available in the market is currently being evaluated; and the revision to the ROC has not been finalized and approved. As a consequence, this program will require careful monitoring due to the numerous interactions and decisions by the Government and contractor team which are anticipated during the early materiel acquisition phases.

The three-phase research, development, and procurement process is expected to occur over an eight year period in line with the Army Streamlined Acquisition Process (ASAP). Testing during each phase is as follows:

(1) Proof of Principle Phase (POP). The objective of POP is to develop a system/concept which has effectively suppressed aural and IR battlefield signatures and can provide reliability which is greater than the current 10kW generator sets. During this phase there will be a Technical Feasibility Test and Evaluation (TFT&E) which will conclude and results reported prior to the Milestone I/II In-Process Review (IPR). TFT&E will consist of two parts, technical and user/operational demonstrations.

(a) Technical Demonstration. Testing will be oriented toward analyzing the feasibility of successfully suppressing aural and IR signatures and improve of the generator reliability. Concepts and components will be demonstrated using brassboard prototypes and/or surrogate components or systems.

(b) Troop Demonstration. Representative user troops will be provided with a brassboard prototype of the 10kW SLEEP generator set. These troops will operate and maintain the generator set in accordance with (IAW) the approved Operational and Organizational (O&O) Plan. The test environments will be representative of those proposed for 10kW SLEEP operations (NBC environments are not included).

(2) Development Proveout Phase (DPP). The objective of DPP is to design a comprehensive 10kW SLEEP generator system. Testing of the prototype 10kW SLEEP systems will be conducted and reports developed prior to the Milestone III TC IPR.

(a) Technical Test. Testing will be geared toward assessing the signature suppression effectiveness; achievement of reliability goals; HAEMP survivability; construction; voltage and frequency adjustment and quality; non-interference and susceptibility; and interoperability of the 10kW SLEEP systems.

(b) User Test. Testing will be conducted in an environment which approximates the proposed operational environments for 10kW SLEEP. Particular attention will be directed towards the requirements of the end users, adequacy of documentation, training requirements, battlefield signature, NBC operations, contamination/decontamination survivability, logistical requirements, and provisioning.

(c) Preproduction Test (PPT). Initial production operational concerns will be evaluated to ensure that the 10kW SLEEP generator sets can be manufactured cost effectively and IAW the PD; and that the new system does meet operational requirements. This test will also include the initial Functional Configuration Audit (FCA) and the initial Physical Configuration Audit (PCA). Funds for the hard-tooled prototypes and the testing may be obtained from the Procurement Appropriation (PA). The initiation of PA funded activities with require that an IPR be conducted to approve the action. These activities could include: Initial Production Facilitization (IPF), Long Lead Time Items (LLTI), development of hard-tooled prototypes, and the conduct of a Production Readiness Review (PRR).

(3) Production and Deployment Phase (PDP). Test and evaluation during PDP, Product Acceptance Test, will be address the procurement issues; safe, well manufactured, quality product which fulfills operational objectives and fully complies with the PD. PDP product acceptance testing will include a Final FCA and Final PCA to insure end items meet specifications and production and First Article Test (FAT).

All test dates are yet to be determined.

b. Responsibilities. Table 1 contains the listing of the responsibilities and associated support agency(s) of the 10kW SLEEP program:

TABLE 1. RESPONSIBILITIES

Responsibility	Agency
Project Manager	PM-MEP
Materiel Developer	BELVOIR

(CONTINUED)

TABLE 1. RESPONSIBILITIES (CONTINUED)

Responsibility	Agency
Combat Developer	USAENS
Procuring Agency	TROSCOM
Logistician	US Army Logistics Evaluation Agency (USALEA)
User Representative	USAENS
Technical Demonstration Conductor	BELVOIR/Contractor
Technical Demonstration Independent Evaluator	US Army Test and Evaluation Command (TECOM)
Troop Demonstration Conductor	USAENS
Troop Demonstration Independent Evaluator	US Army Training and Doctrine Command Combined Arms Center (CAC)
Technical Tester	TECOM
Technical Test Independent Evaluator	TECOM
User Tester	US Army Operational Test and Evaluation Agency (OTEA)
User Test Independent Evaluator	CAC
Pre-production Tester	OTEA
Pre-production Test Independent Evaluator	CAC
Product Acceptance Tester	TECOM
Product Acceptance Test Independent Evaluator	OTEA
Trainer	USAENS

c. Decision Points and Documentation Required. The key materiel acquisition decision points (MADP) and the test and evaluation (T&E) documents required to support them are as follows:

(1) Test Integration Working Group (TIWG) Identified

(a) TIWG Charter
(b) TEMP

(2) Milestone I/II IPR, TFT&E Decision

(a) TECOM Technical Demonstration Independent Evaluation Report (IER)
(b) BELVOIR Technical Demonstration Test report
(c) Contractor Technical Demonstration Test report
(d) CAC Troop Demonstration IER
(e) USAENS Troop Demonstration Test report

(3) Approve initiation of Procurement-Funded Activities

(a) TECOM Technical Test IER
(b) TECOM Technical Test report
(c) CAC User Test IER
(d) OTEA User Test report
(e) CAC PPT Independent Evaluation Plan (IEP)

(4) Milestone III IPR, Production Decision

(1) TECOM Technical Test IER
(2) TECOM Technical Test report
(3) CAC User Test IER
(4) OTEA User Test report
(5) CAC PPT IER
(6) OTEA PPT report
(7) PCA report
(8) FCA report

(5) Government Acceptance of Product Acceptance Test Reports

d. Test Data Management. The responsibility for coordinating and sharing of test results and reports will rest with the TIWG. The chairman will ensure that detailed planning and concurrences related to data sharing among the members are achieved prior to the commencement of testing.

PM-MEP has program management responsibility for three other R&D programs to correct the generator problems of the US Army: (1) Quiet Tactical Generators, (2) Signature Suppressed Diesel Engine Driven Generator Sets, and (3) Commercial Generator Set Assemblages. The objective of these programs is to develop a family of tactical generators to meet the long term reduced signature generator needs of the Army. Signature suppression data and test results should be shared between these programs to eliminate duplicate efforts. An organizational liaison between these programs will be established by PM-MEP to guarantee a complete exchange of information.

e. Termination of Testing. The determination to terminate testing will be the responsibility of the TIWG, as defined by criteria that will be

agreed to and approved by TROSCOM. A test's termination may be for either favorable or unfavorable results. Testing may be suspended for unfavorable results when the equipment is judged unable to meet the aural and IR suppression and/or reliability requirements, or poses an undue hazard to personnel or equipment. Upon termination, test reports will be developed and an IPR will be conducted to consider future actions.

f. Schedule, Resource, and Budget Constraints. Fielding dates for the 10kW SLEEP sets may constrain T&E events and activities. Specific schedule constraints will be addressed in the update of this TEMP when the development schedule is finalized. Budget constraints will be a principal agenda item at all TIWG meetings. Expenditures will be reviewed at least quarterly by the TIWG chairman. Cost schedules will be updated and submitted to the chairman monthly by all testing agencies and organizations.

g. Related Programs. Therefore, 10kW SLEEP is not in competition with these programs. Signature suppression data and test results should be shared between these programs to eliminate duplicate efforts.

2. INTEGRATED PROGRAM SCHEDULE

The 10kW SLEEP Milestone Schedule is depicted in Table 2 which follows. Acquisition process is expected to encompass a period of eight years. Since the program is in the early stages of the POP, there are a number of unknown dates. This TEMP is a "living" document, and in that context, these dates will be filled in or changed after review by the TIWG and as program events occur. Figure 1 highlights the major events in GANTT Chart format.

TABLE 2. ARMY STREAMLINED ACQUISITION PROCESS MILESTONE SCHEDULE FOR THE 10KW SLEEP GENERATOR

EVENT	DATE	RESPONSIBLE AGENCY
Program Initiation		
Requirements and Technology Base Activity		BELVOIR
Materiel Acquisition Review Board (MARB)		TRADOC
Initial ROC Approval	04 Jun 75	TRADOC

(CONTINUED)

TABLE 2. ARMY STREAMLINED ACQUISITION PROCESS MILESTONE SCHEDULE FOR THE 10KW SLEEP GENERATOR (CONTINUED)

EVENT	DATE	RESPONSIBLE AGENCY
Revised ROC		
Drafted	10 Jan 84	TRADOC
Approved	To be Determined (TBD)	TRADOC
POP	Year 1-2	
Market Investigation	3 Months*	BELVOIR
Verify Design and Engineering	3 Months*	BELVOIR
Functional PD	6 Months*	BELVOIR
Issue Brassboard Prototype Solicitation Packages	TBD	BELVOIR
Award Brassboard Prototype Contracts	TBD	BELVOIR
Brassboard Prototype	12 Months	Contractor
TFT&E		
Technical Demonstration	3 Months**	BELVOIR/Contractor
Troop Demonstration	3 Months**	USAENS
Milestone I/II	Year 2	TROSCOM
DPP (6.4/PA)	Year 2-6	
Issue Prototype System Solicitation Packages	TBD	BELVOIR
Award Prototype System Contracts	TBD	BELVOIR
Prototype System Developed	18 Months	Contractor
Technical Test and Evaluation	6 Months*	TECOM
User Test and Evaluation	6 Months*	OTEA
PD	6 Months*	BELVOIR
Complete Technical Data Package (TDP)	6 Months*	Contractor

(CONTINUED)

TABLE 2. ARMY STREAMLINED ACQUISITION PROCESS MILESTONE SCHEDULE FOR THE 10KW SLEEP GENERATOR (CONTINUED)

EVENT	DATE	RESPONSIBLE AGENCY
IPF	6 Months**	TROSCOM
Procure LLTI	1 month **	BELVOIR
Issue PPT Prototype System Solicitation Packages	TBD	TROSCOM
Award PPT Prototype System Contracts	TBD	TROSCOM
PPT (Hard-Tooled Prototypes)	6 Months	Contractor
PRR	1 Month	TROSCOM
Solicitation Document Developed for Production Units	6 Months**	BELVOIR
Milestone III	Year 6	
PDP (PA/OMA)	Year 6-8.5	
Product Acceptance Test		TECOM
FAT	TBD	TECOM
First Unit Equipped (FUE) (Materiel Release)	TBD	USAENS
Initial Operational Capability (IOC)	TBD	USAENS

NOTE:

1. The dates with * are events that can be scheduled concurrently during POP and DPP.

2. The dates with ** are events that can be scheduled concurrently during POP and DPP.

EVENT/ACTIVITY	FISCAL YEAR 87	88	89	90	91	92	93	94	95
POP									
MARKET INVESTIGATION									
VERIFY DESIGN AND ENGINEERING									
FUNCTIONAL PD									
ISSUE BRASSBOARD PROTOTYPE SOLICITATION PACKAGES		*							
AWARD BRASSBOARD PROTOTYPE CONTRACTS		*							
BRASSBOARD PROTOTYPE									
TFT&E									
TECHNICAL DEMONSTRATION									
TROOP DEMONSTRATION									
MILESTONE I/II				*					
DPP (6.4/PA)									
ISSUE PROTOTYPE SYSTEM SOLICITATION PACKAGES				*					
AWARD PROTOTYPE SYSTEM CONTRACTS				*					
PROTOTYPE SYSTEM DEVELOPED									
TECHNICAL TEST AND EVALUATION									
USER TEST AND EVALUATION									
PD									
COMPLETE TDP									
IPF						TBD			
PROCURE LLTI						TBD			
ISSUE PPT PROTOTYPE SYSTEM SOLICITATION PACKAGES						TBD			
AWARD PPT PROTOTYPE CONTRACTS							TBD		
PPT (HARD-TOOLED PROTOTYPES)							TBD		
PRR							TBD		
SOLICITATION DOCUMENT DEVELOPED FOR PRODUCTION UNITS							TBD		
MILESTONE III								TBD	
PDP (PA/OMA)YEAR									
PRODUCT ACCEPTANCE TEST								TBD	
FAT								TBD	
FUE (MATERIEL RELEASE)									TBD
IOC									TBD

3. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX

a. Integrated Test Schedule. The information displayed at Annex 1.A and Annex 1.B, Integrated Test Schedule and Data Source Matrix (ITSDSM), represents the issues expected to be addressed during TFT&E. The test objectives and issues that are identified were extracted from PART I, paragraph 5.

b. Data Source Matrix. The ITSDSM at Annex 1 includes a data source matrix. The right hand columns indicate the agency or source for test responsibility.

c. Test Facility Certification. The TIWG will identify the issues, either critical or non-critical, and determine which issues require testing in certified test facilities. Issues requiring certified test facilities will be included in Appendix B, Bibliography of Test Facility Certifications. Requirements for test facility certification for any given issue is identified in the ITSDSM at Annex 1.

PART III - DEVELOPMENTAL TEST AND EVALUATION OUTLINE

1. CRITICAL DEVELOPMENTAL TEST AND EVALUATION ISSUES AND CRITERIA

a. General. The critical technical issues associated with TFT&E (Technical Demonstration), Technical Testing, PPT, and Product Acceptance Testing which impact on the performance of the 10kW SLEEP generator sets relate to the areas of electrical output, detectability, NBC survivability, transportability, and reliability. The specific areas at issue for the 10kW SLEEP units follow:

b. Critical Developmental Issues.

(1) Will the performance characteristics of the 10kW SLEEP fulfill the defined Army mission? Tests in this area will determine the generators' electrical output characteristics and assess their starting and performance capabilities in the specified environments. This issue will be resolved during the Technical Demonstration and Technical Testing.

(2) Are the sets fabricated from compatible metals and materials that are inherently corrosion resistant or are treated to inhibit corrosion and deterioration? The materials and coatings used in the fabrication of the 10kW SLEEP will resist deterioration and corrosion related to exposure and storage as described in the Technical Characteristics and Issues. This issue will be resolved during Technical Testing, PPT, and Product Acceptance Testing.

(3) Are the 10kW SLEEP ruggedly constructed? Will the 10kW SLEEP withstand the rough handling encountered during normal generator operations or transportation by rail, truck, fixed wing aircraft, and rotary wing aircraft? The generators' battlefield durability and reliability will be evaluated. This issue will be resolved during Technical Testing and PPT.

(4) Can the operator of a 10kW SLEEP adequately regulate the voltage and frequency of the generator's output? The generator's voltage and frequency regulators and gauges will be evaluated for effectiveness, convenience, and ease of comprehension. This issue will be resolved during the Technical Demonstration.

(5) Can the 10kW SLEEP be safely transported? Are sets volume and weight compatible with the designated prime movers and MIL-STD chassis and trailers? The 10kW SLEEP lift and tie-down provisions and procedures will be examined, movement and slippage data will be collected, and adherence to the volume and weight limitations identified in the PD and ROC determined. These issues will be resolved during the Technical Test and PPT. Transportation data will be incorporated in the Logistics Support Analysis (LSA).

(6) Can the 10kW SLEEP survive the effects of NBC contamination and decontamination and continue to effectively provide electrical power to supported systems? The sets will withstand contamination and decontamination while providing electrical power IAW MIL-STD-1332. The

blueprints of the 10kW SLEEP sets will be reviewed to ensure cracks, crevices, corners, and hidden surfaces, that would trap NBC contaminants, decontaminants, and other unwanted fluids are avoided. This issue will be resolved during the Technical Test and PPT.

(7) Will the generator sets survive the effects of HAEMP? Generators are integral to mission accomplishment; therefore, the 10kW SLEEP are required to survive HAEMP. This issue will be resolved during the Technical Test.

(8) Will the 10kW SLEEP handle brief overload conditions? Air conditioners and other systems require an excessive amount of voltage/amps, in-rush current, to start electric motors; therefore, the 10kW SLEEP must sustain brief overloads IAW MIL-STD-1332. This issue will be resolved during the Technical Demonstration, Technical Testing, and PPT.

(9) Will the 10kW SLEEP effectively interface with DISE? This issue will be resolved during the Technical Demonstration.

(10) Will the on-board fuel capacity of the sets capable of supporting 12 continuous hours of operation at mission load? This issue will be resolved during the Technical Demonstration, Technical Testing, and PPT.

(11) Will personnel be able to safely operate the 10kW SLEEP? The sets shall meet the provisions of MIL-STD-882, MIL-STD-1472C 5.13 and MIL-STD-454 Requirement 1. This issue will be resolved during the Technical Demonstration, Technical Test, PPT, and Product Acceptance Testing.

(12) Will the generator sets interfere with mission essential communication, data processing, and other equipment being supported? The 10kW SLEEP will not emit EMI and will meet the requirements of MIL-STD-461. This issue will be resolved during the Technical Test, PPT, and Product Acceptance Testing.

2. DEVELOPMENTAL TEST AND EVALUATION TO DATE

None.

3. FUTURE DEVELOPMENTAL TEST AND EVALUATION

a. Proof of Principle Phase.

(1) Equipment Description. Two 10kW SLEEP brassboard prototypes of each mode, for a total of six, will be examined. The TFT&E prototypes will be the least complex the prototypes developed; TFT&E prototypes will be exploratory systems designed to demonstrate the concept and the technology available. TFT&E will examine the technical feasibility of adequately suppressing aural and IR signatures.

(2) Developmental Test and Evaluation Objectives. TFT&E will assess the possibilities of aural and IR suppression and reliability improvements for 10kW tactical generator sets. The demonstration and confirmation of the 10kW SLEEP concept are the goals of TFT&E. The TFT&E sets shall provide the required electrical output (to include voltage and frequency adjustment), have low aural and IR signatures, satisfy size and weight constraints, interface with DISE, handle brief overload periods, provide a fuel system which efficiently supports 12 continuous hours of operations at rated load, and have tactical mobility. Contractor testing will also include evaluation of technology which can be incorporated into future 10kW SLEEP prototype systems. Conclusions reached and data collected from this demonstration will be used for the Milestone I/II IPR "go/no go" decision.

(3) Key Developmental Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. The focus will be reliability, aural and IR signature suppression technologies, electrical output, and transportability as required in the PD. The tests will be conducted at Government and contractor facilities; manufacturer testing will be supervised and evaluated by Government engineers. Specific test events for TFT&E will be developed at a later date.

(b) Scope of Testing. TFT&E will be conducted on prototypes and promising subsystem technologies. The test will be structured to address critical issues pertinent to PPP (refer to Part III, paragraph 1 or the ITSDSM) and the PD. The test environment for TFT&E will include both "laboratory" and operational mission profiles. Testing to be performed will address: endurance, reliability, transportation, fuel system, fuel and lubricant requirements, electrical power production, DISE compatibility, and environmental survivability. Testing will also include an operational mission profile test to simulate actual field usage, as closely as possible. Satisfactory results to all tests of critical technical issues will ensure that all test objectives have been met. A more detailed scope of testing will be developed as the program is more defined and IEPs are developed.

(c) Scenarios. At this time there are no basic scenario requirements for TFT&E.

b. Development Proveout Phase.

(1) Equipment Description.

(a) Technical Test. The prototypes used in the Technical Test may or may not resemble the TFT&E brassboard prototype. The Technical Test models will be aural and IR signature suppressed, have limited nuclear hardening (protection from the effects of HAEMP), be NBC contamination and decontamination survivable, be painted with CARC, have multi-fuel engines, be ruggedized for performance in the designated military environments, have full tactical and strategic mobility, and produce little or no EMI signals.

These prototypes will incorporate advanced technologies and permit the integration of new technologies as they are proven.

(b) PPT. The preproduction units will be multi-fueled generators which are enhanced versions of the Technical Test prototypes with any design problems found during the Technical Test corrected. These units will be evaluated during pre-production testing to ensure that the manufacturer(s) has(have) properly tooled and the systems comply with the PD. The results of the PPT will be used to determine the definitive type classification of the 10kW SLEEP sets. This test will be geared toward finalizing the TDP and production PD.

(2) Developmental Test and Evaluation Objectives.

(a) Technical Test. The key objective of Technical Testing is to assess the ability of the complete 10kW SLEEP system in fulfilling the Army's 10kW mobile power generation requirements. The Technical Test sets shall fulfill aural and IR signature suppression requirements, satisfy the improved reliability requirements (as compared to current 10kW systems), have full tactical and strategic mobility, survive the effects of HAEMP, produce little or no EMI signals, assess the adequacy of the system support package (SSP), effectively interface with DISE, and confirm the multi-fuel capability. The design of the Technical Test 10kW SLEEP generator units and modifications arriving from test results, will be used to in designing the PPT prototypes, therefore, the test goal is to design a system which is nearly ready to go into production.

(b) PPT. This test shall be geared toward assessing the quality of the production tooling the manufacturer(s) use and assuring that production of the 10kW SLEEP is prudent. These pre-production unit shall fulfill the mobile power generation technical and environmental requirements as stated in the SLEEP ROC. The 10kW SLEEP sets will have low aural and IR battlefield signatures, high reliability, NBC contamination and decontamination survivability, complete tactical and strategic mobility, HAEMP protection, minimum EMI signals, and an efficient multi-fuel engine. The test, PCA, and FCA results will be used to determine the definitive TDP which will go to the Milestone III TC IPR.

(3) Key Developmental Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. The Technical Tests and PPT will examine the 10kW SLEEP sets as a total 10kW power generation system. System examination will include SSPs, TMDE, technical manuals, training manual, training equipment. The generator sets will also be judged for reliability, aural and IR signature suppression, electrical output, and transportability. The tests will be conducted at Government and contractor facilities; manufacturer testing will be supervised and evaluated by Government engineers. Technical Test and PPT event specifics will be developed at a later date.

(b) Scope of Testing. Technical Tests and PPT will be structured to ensure that all critical technical issues, Part I, paragraph

5.a., are closely scrutinized. The test environment will include both "laboratory" and operational mission profiles. The tests will address endurance; reliability; electrical power production; DISE compatibility; use of compatible materials; CARC application; maximum power; transportation: rail transportation IAW American Association of Railroads (AAR) Test Procedures for Rail Shipment, air transportability IAW MIL-A-8421, road test (the generator will be mounted on the appropriate trailer and towed over the road conditions specified in the technical issue); NBC contamination and decontamination survivability and compatibility with NBC decontamination procedures; temperature and humidity damage IAW method 711.1 of MIL-STD-705; fuel test (multi-fuel requirement) IAW MIL-STD-705; fuel system inspection; fuel and lubricant requirements; HAEMP Section 3 of PD; EMI IAW MIL-STD-462, Appendix A; starting; environmental survivability; and a physical examination for conformance to PD and drawings. A more detailed scope of testing will be developed as the program is more defined and IEPs are developed.

(c) Scenarios. At this time the Technical Test and PPT do not have basic scenario requirements.

c. Production and Deployment Phase.

(1) Equipment Description. The Product Acceptance Test units will essentially be the same as the PPT units except for design corrections required as a result of PPT.

(2) Developmental Test and Evaluation Objectives. The Product Acceptance Test will be composed of three parts: Final PCA, FAT, and Final FCA. The Final PCA will examine the full production tooling of the manufacturer(s); the FAT will verify the acceptability of each 10kW SLEEP type; and the Final FCA will validate the attainment of performance specifications.

(3) Key Developmental Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. Product Acceptance Tests will focus on procuring a fully operational, quality product for field troops. The FAT will examine reliability, aural and IR signature suppression, electrical output, and transportability. The FCA will verify that the system has achieved the performance specified in the PD, specifications, and SLEEP ROC. The Final PCA will ensure that the manufacturers have met the requirements specified in the PD and specifications. The Government will approve the production units after satisfactory accomplishment of the Final FCA, Final PCA, and FAT. Testing will be conducted at Government and contractor facilities; manufacturer testing will be supervised and evaluated by Government engineers. Product Acceptance Test events will be detailed at a later date.

(b) Scope of Testing. Product Acceptance Tests will be structured to scrutinize critical production and deployment issues pertinent (refer to Part I, paragraph 5.a. or Part III, paragraph 1) and PD. The test environment could be termed "laboratory". Product Acceptance Testing for

the 10kW SLEEP sets will be primarily concerned with physical and functional examination, ensure SSP is adequate, and evaluating conformance with PD, specifications, and drawings. A more detailed scope of testing will be developed as the program is more defined and IEPs are developed.

(c) Scenarios. There are no scenario requirements for Product Acceptance Testing.

4. PREPRODUCTION QUALIFICATION TEST AND EVALUATION

The PPT will serve as the preproduction qualification test. This test will verify that the manufacturer(s) can produce generator sets which are in compliance with the requirements of the PD. The PPT will also provide technical T&E data to support the Milestone III decision to TC the 10kW SLEEP as Standard for Army-wide fielding. Inspections (PCA and FCA) and tests of the preproduction 10kW SLEEP units will be conducted IAW the test procedures specified in the preproduction PD and preproduction prototype contract. The tests will be either conducted or monitored by Government personnel.

5. PRODUCTION QUALIFICATION TEST AND EVALUATION

a. Production Qualification and Acceptance Tests to Date. None.

b. Future Production Qualification and Acceptance Tests. The Product Acceptance Test will serve as the production qualification test to verify manufacturer compliance with the requirements of the PD. The Product Acceptance Test will be conducted after the Milestone III decision to TC Standard the 10kW SLEEP generator sets. The Product Acceptance Test will include Final FCA, Final PCA, FAT, and the Government will conduct sample lot inspections and individual quality conformance tests (successful completion of these inspections is required for acceptance). Requirements of sample lot and quality conformance tests will be detailed in future updates of this TEMP and the PD for full scale production of the 10kW SLEEP generator sets.

c. Critical Resources. The Product Acceptance Test will be performed on initial production sets of each mode randomly selected by the Government. The manufacturer(s) will produce these units with production tooling. The resources necessary to conduct the tests will be the responsibility of the contractor unless otherwise specified in the production contract or PD. The resources will include instrumentation, facilities and experience. Product Acceptance Test resource requirements will be detailed in future updates of this TEMP.

6. SOFTWARE VERIFICATION AND VALIDATION

Not applicable.

7. SPECIAL RETEST REQUIREMENTS

None at this time.

8. CRITICAL RESOURCES

Brassboard prototype units of each 10kW SLEEP model are critical to the conduct of TFT&E. Currently 2 units of each generator model are be required for TFT&E. TFT&E will require the manufacturer(s) to provide spare parts provisioning, hardware maintenance support, documentation and manuals for the 10kW SLEEP, and field engineers who can demonstrate the prototype system. The test agency and contractor shall provide personnel with appropriate skills and experience in generator operation or maintenance, standard TMDE, and appropriate facilities.

PART IV - OPERATIONAL TEST AND EVALUATION OUTLINE

1. CRITICAL OPERATIONAL TEST AND EVALUATION ISSUES

a. General.

The 10kW SLEEP Program requires Operational Test and Evaluation (OT&E). Operational issues and performance capabilities of the systems will be evaluated during the TFT&E Troop Demonstration, User Test, PPT, and Product Acceptance Testing. The operational issues which are critical to the 10kW SLEEP relate to the system's compatibility with prime movers, battlefield signatures, electric power suitability, performance in the operational environment, transportability, NBC contamination and decontamination survivability, HAEMP hardening, system supportability, human factors engineering (HFE), health and safety, MANPRINT, and RAM-D.

b. Critical Operational Issues.

The TFT&E Troop Demonstration, User Test, PPT, and Product Acceptance Testing will evaluate the critical operational issues which are summarized below:

(1) Are the 10kW SLEEP generator sets compatible with their designated prime movers? This issue will assess system mobility, size and weight specifically ability of the units to fit in selected trailers, compatibility with prime movers, and ability to use the same standard military fuels, lubricants, and coolants as their prime movers. This issue will be evaluated and resolved during the User Test, PPT, and Product Acceptance Testing.

(2) Has the battlefield signature been adequately reduced? This issue will determine the equipment's aural detectability envelope. The battlefield signatures will be evaluated and resolved during the Troop Demonstration, User Test, PPT, and Product Acceptance Testing.

(3) Can the 10kW SLEEP generator sets provide the required electric power in an operational environment? Tests conducted to address this issue will determine the suitability of the electric power the generator sets provide. The sets will be judged for electric power type and quality, when the equipment is used under operational conditions. Moreover, these test shall be designed to judge operational ability of the generator sets with respect to: climate, even and uneven terrain, protection against destructive malfunctions, starting at specified temperatures and altitudes, accuracy of fluid level indicators, and storage in extremes of temperature. This issue will be evaluated and resolved during the Troop Demonstration, User Test, and PPT.

(4) Are the 10kW SLEEP generator sets adequately designed relative to MANPRINT principles? This issue will determine if the final design of the equipment considered the soldier as one of its subsystems. This issue will be resolved during the User Test and PPT.

(5) Can the 10kW SLEEP be safely operated and maintained by the soldiers? The sets shall meet the provisions of MIL-STD-882, MIL-STD-1472C 5.13 and MIL-STD-454 Requirement 1. Testing will determine if operating personnel will be exposed to any uncontrolled health or safety hazards. This issue will be resolved during the Troop Demonstration, User Test, PPT, and Product Acceptance Testing.

(6) Are the 10kW SLEEP generator sets adequately designed relative to HFE principles? This issue will determine if HFE principles and considerations were incorporated in the final design of the equipment. This issue will be evaluated and resolved during the User Test, PPT, and Product Acceptance Testing.

(7) Can the 10kW SLEEP generator sets be substituted for the existing DOD 10kW generator sets? This issue will determine if the 10kW SLEEP generator sets can replace and be interchangeable with the DOD standard 10kW generator sets of comparable mode. This issue will be evaluated during the User Test and PPT.

(8) Are the 10kW SLEEP generator sets capable of worldwide transport by air, marine, highway, and rail? This issue will validate transportability characteristics to include LVAD and LAPES techniques. The Troop Demonstration will examine possible transportability problems that may occur; however, this issue will be resolved during User Test and PPT. Transportability data will be incorporated in the LSA.

(9) What are the logistical support requirements of the 10kW SLEEP? Are the 10kW SLEEP logistically supportable and sustainable in the field? The 10kW SLEEP generator sets' impact on the Army logistics support structure will be evaluated and support requirement data collected. This issue will assess the support concept, use of standard tools and test equipment, availability of spares and repair parts, and the adequacy of technical manuals and training documentation. The data will be validated and included in the LSA. This issue will be evaluated and resolved during the Troop Demonstration, User Test, and PPT. The Product Acceptance Test will measure the adequacy of the ILS in place for fielding.

(10) Will the 10kW SLEEP generator sets survive and operate effectively in a NBC environment? This issue will assess the equipment's contamination and decontamination survivability, operation and maintenance by personnel wearing full NBC protective garments, and compatibility with standard NBC protection equipment. This issue will be evaluated during the User Test and PPT.

(11) Can personnel selected to operate and maintain the new generator sets perform their required duties? A manpower and skill level appraisal will be conducted. The 10kW SLEEP's manpower requirements, in both numbers and types, shall be compatible with the manpower associated with existing DOD generator sets. This data will be validated and provided to the logistician for inclusion in the LSA. This issue will be evaluated and resolved during the Troop Demonstration, User Test, and PPT.

(12) Is the 10kW SLEEP training program adequate? This issue will assess the NET program for key personnel, provisions for formal system training, and the training and maintenance documentation. The NET test results be provided to the logistician and the LSA shall be updated. The Troop Demonstration will be structured to determine the amount and type of NET will be required for the fielded systems. This issue will be evaluated and resolved during the User Test and PPT.

(13) Are the demonstrated RAM-D characteristics adequate? This issue will validate the equipment's MTBF, operational availability, maintenance ratio, scheduled PMCS frequency, scheduled maintenance service frequency, durability, and service life. The Troop Demonstration test approach is to gather initial 10kW SLEEP RAM-D data to ascertain whether future systems can achieve the required goals. This issue will be resolved during the User Test and PPT.

2. OPERATIONAL TEST AND EVALUATION TO DATE

None.

3. FUTURE OPERATIONAL TEST AND EVALUATION

a. Proof of Principle Phase.

(1) Equipment Description. The Troop Demonstration will employ the same brassboard prototypes used in the Technical Demonstration portion of TFT&E, two of each mode, six total. The TFT&E prototypes will be exploratory systems designed to demonstrate the technical and operational concepts. These units will be the least complex prototypes developed. The TFT&E Troop Demonstration will examine the logistical plans, NET requirements, and operational aural and IR signatures. The sets shall provide the required electrical output (to include voltage and frequency adjustment), have low aural and IR signatures, satisfy size and weight constraints, interface with DISE, handle brief overload periods, provide a fuel system which efficiently supports 12 continuous hours of operations at rated load, and have tactical mobility. The sets shall be type I (Tactical), Class 2 (Utility) and shall be rated for each of the modes as follows:

(a) Mode II - 10kW, 400 Hz; 0.8 power factor, lagging; 120/208 V, three phase, 4 wire reconnectable to 120/240 V, single phase, 3 wire and 120 V, single phase, 2 wire.

(b) Mode III - 10kW, 60 Hz; 0.8 power factor, lagging; 120/208 V, three phase, 4 wire reconnectable to 120/240 V, single phase, 3 wire and 120 V, single phase, 2 wire.

(c) Mode IV - 10kW, DC; 28 Vdc, 357 amperes, 2 wire.

(2) Operational Test and Evaluation Objectives. The TFT&E Troop Demonstration will appraise the 10kW SLEEP concept with regard to aural and IR suppression in the operational environment and requirements for NET, manpower, and Military Occupational Specialty (MOS) codes. The demonstration and verification of the operational 10kW SLEEP concept are the goals of the

TFT&E Troop Demonstration. Testing will concentrate the users' reliability, maintainability, aural and IR signatures, electrical output, and transportability requirements. This data will form the basis for the LSA. Designing an effective system which is logistically supportable is the chief goal of this program.

(3) Key Operational Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. The tests will be conducted at Government facilities. Specific test events for the TFT&E Troop Demonstration will be developed at a later date.

(b) Scope of Testing. The Troop Demonstration will be conducted using brassboard prototype systems. The test will provide the user an opportunity to experiment with the proposed system and tailor its capabilities, NET, and equipment documentation. The test will address critical issues pertinent to PPP (refer to Part IV, paragraph 1 or the ITSDSM) and the PD. The test environment will simulate the operational mission profiles anticipated for this equipment. Areas of interest include: DISE compatibility, electrical power production, endurance, environmental survivability, fuel consumption, fuel system safety, fuel and lubricant requirements, maintainability, reliability, and transportation. Testing will also include an operational mission profile test to simulate actual field usage, as closely as possible. Satisfactory results to all tests of critical operational issues will ensure that all test objectives have been met. A more detailed scope of testing will be developed as the program is more defined and IEPs are developed.

(c) Scenarios. At this time there are no basic scenario requirements for TFT&E Troop Demonstration.

(d) Test Limitations. The immaturity of the TFT&E prototypes, length of time to conduct the user evaluation, the availability of brassboard prototype models for the TFT&E Troop Demonstration, adequacy of equipment documentation, and equipment durability are the only limitations at this time. The major limitation immaturity of the system may affect critical issue evaluation; however, it should be noted that this test is designed to confirm the viability of continuing the 10kW SLEEP program.

b. Development Proveout Phase.

(1) Equipment Description.

(a) User Test. The Technical and User Tests will share a total of 36 prototype systems, 12 of each mode. The prototypes used during the Technical/User Tests may or may not resemble the TFT&E brassboard prototypes. The test models will have aural and IR signature suppression, protection from HAEMP effects, NBC contamination and decontamination survivability, CARC, multi-fuel engines, rugged construction for military operations, complete mobility, and produce little or no EMI signals.

(b) PPT. The preproduction units will be multi-fueled diesel generators which are enhanced versions of the Technical/User Test prototypes with any design problems found during the Technical and User Tests corrected. The operational testing conducted during PPT will ensure that the preproduction units will meet the users requirements (i.e., complied with the operational portions of the PD and ROC). This test will be geared toward finalizing the operational characteristics of the production models.

(2) Operational Test and Evaluation Objectives.

(a) User Test. The key objective of User Testing is to assess the ability of the complete 10kW SLEEP system (generator sets, NET, documentation, TMDE, and ILS) in fulfilling the Army's 10kW mobile power generation requirements. The Technical/User Test sets shall suppress battlefield signatures, improve RAM-D, achieve full mobility, survive HAEMP, produce low to no EMI signals, interface with DISE, provide complete equipment publications, achieve NET requirement, and achieve a multi-fuel operational capability. The test goal is to ensure that the system is nearly ready to enter into production (operational and logistics issues satisfied) and provide and collect LSA data.

(b) PPT. The operational portions of this test shall furnish production/fielding readiness data and assure that the ILS structure is adequate. These preproduction unit shall fulfill the mobile power generation operational and environmental requirements as stated in the SLEEP ROC. The 10kW SLEEP sets will have low operational battlefield signatures, high reliability, NBC contamination and decontamination survivability, complete tactical and strategic mobility, HAEMP protection, minimal EMI signals, and an efficient multi-fuel engine. The FCA results will be used to verify the functional capabilities which will be expected of the production models.

(3) Key Operational Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. The User Tests and PPT will examine the 10kW SLEEP sets as a total 10kW power generation system. System examination will include SSPs, TMDE, technical manuals, training manual, training equipment. The generator sets will also be judged for reliability, aural and IR signature suppression, electrical output, and transportability. The tests will be conducted at Government and contractor facilities; manufacturer testing will be supervised and evaluated by Government engineers. User Test and PPT event specifics will be developed at a later date.

(b) Scope of Testing. User Tests and PPT will be structured to ensure that all critical operational issues, Part I, paragraph 5.b., are properly evaluated. The tests will be conducted in environments which closely parallel the proposed operational environments. The tests will address safety; maintainability (employing the SSP, maintenance concept, and logistics structure); reliability; endurance; environmental survivability; electrical power production; DISE compatibility; maximum power; rail and air transportability; road test; trailer compatibility; NBC contamination and decontamination survivability and compatibility with NBC decontamination

procedures; NBC operations and maintenance; cold weather operations and maintenance; fuel and fluid gage tests; fuel system safety; fuel and lubricant requirements (consumption and type); EMI signals IAW MIL-STD-462, Appendix A; and starting (normal and cold weather). A more detailed User Test and PPT test scope will be developed as the program is more defined and IEPs are developed.

(c) Scenarios. At this time the User Test and PPT do not have basic scenario requirements.

(d) Test Limitations. The simulation of cold and NBC operating environments, length of time to conduct the User Test and operational phase of PPT, the availability of prototype systems, adequacy of documentation/support equipment, and equipment durability are the only limitations at this time.

c. Production and Deployment Phase.

(1) Equipment Description. The Product Acceptance Test units will essentially be the same as the PPT units except for design corrections required as a result of PPT.

(2) Operational Test and Evaluation Objectives. The operational objectives of the Product Acceptance Test are to verify full production readiness of the 10kW SLEEP generator sets, support structure, provisioning, NET, and equipment publications. The Final FCA portion of the Product Acceptance Test will specifically examine the functional readiness of the new generator sets, ensure that the equipment can perform the functions intended. The Product Acceptance Test will verify acceptability of the 10kW SLEEP's operational performance and fulfillment of functional specifications.

(3) Key Operational Test and Evaluation Events, Scope of Testing, and Basic Scenarios.

(a) Events. Product Acceptance Tests will focus on procuring an effective, fully operational (including ILS), quality product which can be operated and maintained by field troops. The Final FCA will verify that the system has achieved the functional performance specified in the PD, equipment specifications, and ROC. The Government will approve the production units after satisfactory accomplishment of the Final FCA, Final PCA, and FAT. Testing will be conducted at Government facilities. Product Acceptance Test events will be detailed at a later date.

(b) Scope of Testing. Product Acceptance Tests operational scope is to examine production and deployment issues critical to equipment fielding and operational effectiveness (i.e., NET, provisioning, and ILS). The test environment could be regarded as "laboratory". Product Acceptance Test operational testing of the 10kW SLEEP sets will be primarily concerned with functional examination; adequacy of the SSP, NET, provisioning, and ILS; and conformance with PD, specifications, and drawings. A more detailed operational Product Acceptance Test scope will be developed as the program

is more defined and IEPs are developed.

(c) Scenarios. There are no scenario requirements for Product Acceptance Testing.

(d) Test Limitations. The length of time to conduct the Product Acceptance Test and the availability of production models are the only limitations at this time.

4. CRITICAL RESOURCES

The TFT&E Troop Demonstration will require two brassboard prototype units of each 10kW SLEEP mode (six total). For proper conduct of the TFT&E Troop Demonstration the manufacturer(s) are required to provide spare parts provisioning, hardware maintenance support, equipment publications, 10kW SLEEP specialized TMDE, and field engineers who can demonstrate the prototype system. The test agency and contractor(s) shall provide DISE equipment, standard and specialized TMDE, suitable facilities, and personnel with appropriate skills and experience in generator operation or maintenance. If required, certified test facilities will be provided and certification requirements incorporated in this TEMP and all procurement documents.

PART V - SPECIAL TEST RESOURCES

1. TEST ARTICLES

The manufacturers are required to furnish spare and repair parts, hardware maintenance support, specialized tools, equipment publications for the 10kW SLEEP equipment, and field engineers to demonstrate the equipment. The test agencies shall provide personnel with the requisite skills and experience in generator operation/maintenance, suitable facilities, and standard TMDE. Testing will occur at contractor and Government laboratories. Requirements for certified test facilities will be determined by the TIWG. As the certified facility requirements become available they will be incorporated into the TEMP.

a. Proof of Principle Phase. The TFT&E Technical and Troop Demonstrations will share the test articles. For each generator mode, there will be two brassboard prototype 10kW SLEEP units constructed (six total). The PD upon which the solicitation will be based is scheduled for completion in February 1988.

(1) 10 kW, MODE II	2 UNITS
(2) 10 kW, MODE III	2 UNITS
(3) 10 kW, MODE IV	2 UNITS
TOTAL	6 UNITS

b. Development Proveout Phase.

(1) Technical/User Test Articles. The Technical and User Tests will utilize the same test articles. There will be 12 units fabricated for each 10kW SLEEP generator mode. The goal is to have up to 4 manufacturers for each mode, developing prototype generator sets. The specific quantities are listed below:

(1) 10 kW, MODE II	12 UNITS
(2) 10 kW, MODE III	12 UNITS
(3) 10 kW, MODE IV	12 UNITS
TOTAL	36 UNITS

(2) PPT. There will be 12 preproduction 10kW SLEEP units constructed for the PPT. There will be 1 to 3 manufacturers building the preproduction 10kW SLEEP generator sets. The sets will be produced by the manufacturer(s) using production tooling. Unless otherwise specified in the preproduction contract, the manufacturer(s) are responsible for conducting the tests and supplying the necessary test resources. Included in the

necessary resources are: instrumentation, facilities, and expertise. The specific quantities are listed below:

(1)	10 kW, MODE II	4 UNITS
(2)	10 kW, MODE III	4 UNITS
(3)	10 kW, MODE IV	4 UNITS
	TOTAL	12 UNITS

c. Production and Deployment Phase. The Product Acceptance Test will require 12 production models of each size and mode which will be selected by the Government at random, these sets will be produced by the manufacturer(s) using production tooling. Unless otherwise specified in the production contract, the manufacturer(s) are responsible for conducting the tests and supplying the necessary test resources. Included in the necessary resources are: instrumentation, facilities, and expertise.

(1)	10 kW, MODE II	12 UNITS
(2)	10 kW, MODE III	12 UNITS
(3)	10 kW, MODE IV	12 UNITS
	TOTAL	36 UNITS

d. Test Article Impact. To ensure test articles are manufactured on time and test schedules are met, penalty clauses will be included in all development and production contracts. Test schedules will allow for a period of repair and retest of equipment. The TIWG will develop the repair and retest criteria which will be included in the TEMP and approved by TROSCOM.

2. THREAT SYSTEMS

TABLE 3. Threat Profile.

THREAT SYSTEM	BRIGADE FORWARD	BRIGADE REAR	DIVISION REAR	CORPS
SMALL ARMS	X	X	X	X
ARTILLERY	X	X	X	X
MISSILES	X	X	X	X
ARMED HELICOPTERS	X	X	X	X
FIGHTER BOMBERS	X	X	X	X
DIRECTED ENERGY SYSTEMS	X	X	X	X
SPECIAL PURPOSE FORCES			X	X
UNCONVENTIONAL WARFARE TEAMS			X	X
SABOTEURS			X	X

3. TEST TARGETS

None.

4. TEST SUPPORT

At this time, the type and timing of operating force support is not known.

5. COMPUTER SIMULATIONS, MODELS, AND TESTBEDS

None.

6. TEST SITES AND RANGES

a. Proof of Principle Phase.

(1) TFT&E Technical Demonstration. Testing will be performed in contractor and Government laboratories. There are no range requirements at this time.

(2) TFT&E Troop Demonstration. Testing will be performed at Government facilities. There are no range requirements at this time.

b. Development Proveout Phase.

(1) Technical Test. Testing will be performed in contractor and Government laboratories. Critical issue testing will be conducted in certified facilities. There are no range requirements at this time.

(2) User Test. Testing will be performed at Government facilities. Critical issue testing will be conducted in certified facilities. There are no range requirements at this time.

(3) PPI. Testing will be performed in contractor and Government laboratories. Critical issue testing will be conducted in certified facilities. There are no range requirements at this time.

c. Production and Deployment Phase. The Product Acceptance Test will be conducted at both contractor and Government facilities. Critical issue testing will be conducted in certified laboratories. There are no range requirements at this time.

7. SPECIAL REQUIREMENTS

Limited nuclear survivability is a requirement for the 10kW SLEEPs, and as such, special provisions will be made for HAEMP survivability testing at a later date. IR signature detection will be tested using a representative Forward Looking IR (FLIR) sensor (PAVE TACK capabilities). No other special requirements have been identified.

8. TEST AND EVALUATION FUNDING REQUIREMENTS

a. Proof of Principle Phase.

(1) TFT&E Technical Demonstration. Funding requirements TBD.
(2) TFT&E Troop Demonstration. Funding requirements TBD.

b. Development Proveout Phase.

(1) Technical Test. Funding requirements TBD.
(2) User Test. Funding requirements TBD.
(3) PPT. Funding requirements TBD.

c. Production and Deployment Phase. Product Acceptance Test funding requirements TBD.

PART VI - BIBLIOGRAPHY OF TEST PLANS AND REPORTS

As the test plans and reports become available from the test agencies and organizations supporting the 10kW SLEEP Program (AMC, PM-MEP, BELVOIR, CAC, OTEA, TECOM, TRADOC, TROSCOM, USAENS,USALEA, Contractor(s)), they will be incorporated into the TEMP.

ANNEX 1.A.1. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX - TECHNICAL TEST AND EVALUATION

INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX

TECHNICAL TEST AND EVALUATION

1. 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRICAL ENERGY PLANTS (10KW SLEEP)

2. TEST TITLE - TECHNICAL FEASIBILITY TEST, TECHNICAL DEMONSTRATION

3. TEST OBJECTIVES	4. TEST SCOPE 6. TYPE DATA - TBD		10. PARTICIPANTS								11. CRIT.	
			CONTR	BELVOIR	TRADOC	TECOM	CAC	OTEA	USAENS	USALEA	MET	NOT MET
T(1). ACCEPTABILITY OF PHYSICAL CHARACTERISTICS. DURABILITY. WEIGHT. SIZE. FUEL CAPACITY. T(2). ACCEPTABILITY OF PERFORMANCE CHARACTERISTICS. DISE. OVERLOADS. STARTING.	NOT DAMAGED DURING NORMAL OPERATIONS AND ROUGH HANDLING. SHALL NOT EXCEED 650 POUNDS. SHALL NOT EXCEED 30 CUBIC FEET. SUPPORT 12 CONTINUOUS HOURS OF OPERATIONS COMPATIBLE WITH DISE. SUPPORT SHORT DURATION OVERLOADS IAW MIL-STD-1332. (A) ANY ALTITUDE UP TO 5,000 FEET; (B) TEMPERATURES +120°F TO -25°F; (C) BASE IN PLANES 15° FROM LEVEL (D) 4 ± 1 INCHES OF RAIN PER HOUR IMPINGING THE SET; (E) 355 BTUs PER SQUARE FT PER HR OF SOLAR RADIATION; (F) SAND/DUST CONCENTRATIONS OF 1400 MG PER CUBIC METER; (G) SNOW FALL RATE OF 2 INCHES PER HOUR FOR 12 HOURS; (H) WIND SPEED OF 73 FEET PER SECOND AND GUSTS UP TO 95 FEET PER SECOND; (I) FOG OR SEA SPRAY.	5. TEST CONFIGURATION - BREADBOARD PROTOTYPE SYSTEMS, DEMONSTRATE CONCEPT 7. SCHEDULE - TBD 8. LOCATION - GOVERNMENT - BELVOIR CONTRACTOR - TBD 9. TEST FACILITY CERTIFICATION REQUIREMENT - TBD	P	R P	O	M	O	E	O	E		

KEY: O = OBSERVER ONLY P = PARTICIPATION IN TEST E = EVALUATION OF DATA ONLY R = RESPONSIBLE FOR TEST M = MONITOR TEST

ANNEX 1.A.2. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX - TECHNICAL TEST AND EVALUATION

INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX TECHNICAL TEST AND EVALUATION			10. PARTICIPANTS								11. CRIT.	
1. 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRICAL ENERGY PLANTS (10KW SLEEP) 2. TEST TITLE - TECHNICAL FEASIBILITY TEST, TECHNICAL DEMONSTRATION			CONTR	BELVOIR	TRADOC	TECOM	CAC	OTEA	USAENS	USALEA	MET	NOT MET
3. TEST OBJECTIVES	4. TEST SCOPE 6. TYPE DATA - TBD											
T(2). ACCEPTABILITY OF PERFORMANCE CHARACTERISTICS. VOLTAGE AND FREQUENCY REGULATION. T(4). SAFETY. MECHANICAL COMPONENTS AND MOVING PARTS. USER INTERFACE. LIGHTING.	ABILITY TO REGULATE THE OUTPUT VOLTAGE AND FREQUENCY IAW PD. CONCERNS: ELECTRICAL INSULATION, BURRED OR SHARP EDGES, EXCESSIVE VIBRATION, EXCESSIVE NOISE, EXPLOSION, EXPOSED HIGH TEMPERATURE SURFACES, FIRE, INTERFACE WITH NBC PROTECTION EQUIPMENT, AND TOXIC FUMES. MIL-STD-882, MIL-STD-1472C 5.13, AND MIL-STD-454 REQUIREMENT 1. USE SECURE (BLUE/GREEN) LIGHTING.	5. TEST CONFIGURATION - BREADBOARD PROTOTYPE SYSTEMS, DEMONSTRATE CONCEPT 7. SCHEDULE - TBD 8. LOCATION - GOVERNMENT - BELVOIR CONTRACTOR - TBD 9. TEST FACILITY CERTIFICATION REQUIREMENT - TBD	P	R P	O	M	O	E	O	E		

KEY: O = OBSERVER ONLY P = PARTICIPATION IN TEST E = EVALUATION OF DATA ONLY R = RESPONSIBLE FOR TEST M = MONITOR TEST

ANNEX 1.B.1. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX - OPERATIONAL TEST AND EVALUATION

INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX

OPERATIONAL TEST AND EVALUATION

1. 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRICAL ENERGY PLANTS (10KW SLEEP)

2. TEST TITLE - TECHNICAL FEASIBILITY TEST, TROOP DEMONSTRATION

3. TEST OBJECTIVES	4. TEST SCOPE 6. TYPE DATA - TBD		10. PARTICIPANTS: CONTR	BELVOIR	TRADOC	TECOM	CAC	OTEA	USAENS	USALEA	11. CRIT.: MET	NOT MET
O(1). COMPATIBILITY WITH DESIGNATED PRIME MOVERS. FUELS, LUBRICANTS, AND COOLANTS.	START AND OPERATE USING THE SAME STANDARD MILITARY FUELS, LUBRICANTS, AND COOLANTS AS THEIR DESIGNATED PRIME MOVERS.	5. TEST CONFIGURATION - BREADBOARD PROTOTYPE SYSTEMS, DEMONSTRATE CONCEPT 7. SCHEDULE - TBD	P	O	E	E	M	E	R	E		
O(2). ACCEPTABILITY OF BATTLEFIELD SIGNATURE.	NONDETECTABILITY LIMITS OF TABLE 3 OF MIL-STD-1474 AT A NOMINAL NONDETECTABILITY DISTANCE OF 100-300 METERS.	8. LOCATION - GOVERNMENT - BELVOIR CONTRACTOR - TBD										
O(3). SUITABILITY OF ELECTRIC POWER.	PROVIDE ELECTRIC POWER IAW MIL-STD-1332.											
O(4). ACCEPTABILITY OF OPERATIONAL EFFECTIVENESS CHARACTERISTICS. PERFORMANCE.	OPERATE IN HOT, BASIC, COLD, AND EXTREME COLD CLIMATIC CONDITIONS AS DESCRIBED IN AR 70-38.	9. TEST FACILITY CERTIFICATION REQUIREMENT - TBD										
POSITIONING.	OPERABLE WHEN SITUATED IN ANY DIRECTION ON UNEVEN TERRAIN WITH GRADES TO 15°.											
MALFUNCTION PROTECTION.	PROTECTION AGAINST DESTRUCTIVE MALFUNCTIONS AND HAVE A MANUAL OVERRIDE.											

KEY: O = OBSERVER ONLY P = PARTICIPATION IN TEST E = EVALUATION OF DATA ONLY R = RESPONSIBLE FOR TEST M = MONITOR TEST

ANNEX 1.B.2. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX - OPERATIONAL TEST AND EVALUATION

INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX

OPERATIONAL TEST AND EVALUATION

1. 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRICAL ENERGY PLANTS (10KW SLEEP)

2. TEST TITLE - TECHNICAL FEASIBILITY TEST, TROG° DEMONSTRATION

3. TEST OBJECTIVES	4. TEST SCOPE 6. TYPE DATA - TBD		10. PARTICIPANTS								11. CRIT.	
			CONTR	BELVOIR	TRADOC	TECOM	CAC	OTEA	USAENS	USALEA	MET	NOT MET
O(4). ACCEPTABILITY OF OPERATIONAL EFFECTIVENESS CHARACTERISTICS. FLUID INDICATORS. TRANSPORTABILITY. O(5). ACCEPTABILITY OF SYSTEM SUPPORTABILITY CHARACTERISTICS. LOGISTIC SUPPORT. TOOLS AND TEST EQUIPMENT. MANUALS AND TRAINING DOCUMENTATION. O(7). ACCEPTABILITY OF HUMAN FACTORS ENGINEERING AND HEALTH AND SAFETY CHARACTERISTICS. O(9). ACCEPTABILITY OF DEMONSTRATED RAM-D CHARACTERISTICS. RELIABILITY.	ACCURATE FUEL, LUBRICAPT, AND COOLANT INDICATORS. COMPLY WITH THE PD REQUIREMENTS. SUPPORTABLE BY CURRENT ARMY ORGANIZATIONS, DOCTRINE, AND PROCEDURES. USE STANDARD TOOLS, TMDE, AND STE-ICE. ADEQUATE TECHNICAL MANUALS, TRAINING, AND DOCUMENTATION. ROC AND MIL-STD-1472C. OPERABLE AND MAINTAINABLE BY PERSONNEL WITHOUT UNCONTROLLED HEALTH OR SAFETY HAZARDS. MTBF OF 600 HOURS.	5. TEST CONFIGURATION - BREADBOARD PROTOTYPE CONCEPT SYSTEMS, DEMONSTRATE 7. SCHEDULE - TBD 8. LOCATION - GOVERNMENT - BELVOIR CONTRACTOR - TBD 9. TEST FACILITY CERTIFICATION REQUIREMENT - TBD	P	O	E	E	M	E	R	E		

KEY: O = OBSERVER ONLY P = PARTICIPATION IN TEST E = EVALUATION OF DATA ONLY R = RESPONSIBLE FOR TEST M = MONITOR TEST

ANNEX 1.B.3. INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX - OPERATIONAL TEST AND EVALUATION

INTEGRATED TEST SCHEDULE AND DATA SOURCE MATRIX OPERATIONAL TEST AND EVALUATION			10. PARTICIPANTS								11. CRIT.	
1. 10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRICAL ENERGY PLANTS (10KW SLEEP)			CONTR	BELVOIR	TRADOC	TECOM	CAC	OTEA	USAEMS	USALEA	MET	NOT MET
2. TEST TITLE - TECHNICAL FEASIBILITY TEST, TROOP DEMONSTRATION												
3. TEST OBJECTIVES	4. TEST SCOPE 6. TYPE DATA - TBD											
O(9). ACCEPTABILITY OF DEMONSTRATED RAM-D CHARACTERISTICS. AVAILABILITY. MAINTAINABILITY. DURABILITY.	NOT LESS THAN 94 PERCENT. RATIO OF NOT GREATER THAN 0.05; PMCS ITEMS THAT ARE EASILY ACCESSIBLE; SCHEDULED PMCS NOT LESS THAN 12 HOURS; SCHEDULED MAINTENANCE SERVICE NO MORE FREQUENT THAN 175 HOURS; OIL CHANGED IN 20 MINUTES. OPERATE WITHOUT CRITICAL FAILURE FOR 3,000 HOURS AND MINIMUM LIFE OF NO LESS THAN 12,000 HOURS.	5. TEST CONFIGURATION - BREADBOARD PROTOTYPE CONCEPT SYSTEMS, DEMONSTRATE 7. SCHEDULE - TBD 8. LOCATION - GOVERNMENT - BELVOIR CONTRACTOR - TBD TEST FACILITY CERTIFICATION REQUIREMENT - TBD	P	O	E	E	M	E	R	E		

KEY: O = OBSERVER ONLY P = PARTICIPATION IN TEST E = EVALUATION OF DATA ONLY R = RESPONSIBLE FOR TEST M = MONITOR TEST

APPENDIX A - BIBLIOGRAPHY OF TEST FACILITY CERTIFICATIONS

SECTION 1: CRITICAL ISSUES REQUIRING TESTING IN CERTIFIED TEST FACILITIES

To be developed and approved by the TIWG, if required.

SECTION 2: TEST FACILITY CERTIFICATIONS

There are no requirements for test facility certifications at this time. Any testing of critical issues will be conducted in certified contractor and Government facilities. Test facility certifications and certification requirements shall be incorporated in the TEMP as they become available.

APPENDIX B - CRITICAL ISSUE(S) CHANGES (AUDIT TRAIL)

There have been no changes to the critical issues.

APPENDIX C: ACRONYM LIST

10KW SLEEP - 10 Kilowatt Signature Suppressed Lightweight Electric Energy Plants
AAR - American Association of Railroads
AMC - US Army Materiel Command
AR - Army Regulation
ASAP - Army Streamlined Acquisition Process
BELVOIR - US Army Belvoir Research, Development and Engineering Center
BOC - Best Operational Capability
BTU - British Thermal Unit
C^3I - Command, Control, Communication, and Intelligence
CAC - US Army Training and Doctrine Command Combined Arms Center
CARC - Chemical Agent Resistant Coating
CSS - Combat Service Support
CUCV - Commercial Utility Cargo Vehicle
DA - Department of the Army
DC - Direct Current
DCA - Diagnostic Connector Assembly
DISE - Distribution Illumination Systems, Electrical
DOD - Department of Defense
DPP - Development Proveout Phase
EMI Electromagnetic Interference
FAT - First Article Testing
FCA - Functional Configuration Audit
FLIR - Forward Looking Infrared
FUE - First Unit Equipped
HAEMP - High Altitude Electromagnetic Pulse
HFE - Human Factors Engineering
HMMWV - High Mobility Multi-Purpose Wheeled Vehicle
Hz - Hertz
IAW - In Accordance With
IEP - Independent Evaluation Plan
IEP - Independent Evaluation Plan
IER - Independent Evaluation Report
IOC - Initial Operational Capability
IPF - Initial Production Facilitization
IPR - In-Process Review
IR - Infrared
ITSDSM - Integrated Test Schedule and Data Source Matrix
LAPE - Low Altitude Parachute Extraction
LIN - Line Item Number
LLTI - Long Lead Time Items
LSA - Logistics Support Analysis
LVAD - Low Velocity Air Drop
MADP - materiel acquisition decision points
MANPRINT - Manpower and Personnel Integration
MARB - Materiel Acquisition Review Board
MAV - Minimum Acceptable Value
MEP - Mobile Electric Power
MIL-STD - Military Standard

MOPP	- Mission Oriented Protective Posture
MOS	- Military Operational Specialty
MPH	- Miles Per Hour
MTBF	- Mean Time Between Failure
MTBOMF	- Mean Time Between Operational Mission Failure
NATO	- North Atlantic Treaty Organization
NBC	- Nuclear, Biological, and Chemical
NET	- New Equipment Training
NSN	- National Stock Number
O&O	- Operational and Organizational
OT&E	- Operational Test and Evaluation
OTEA	- US Army Operational Test and Evaluation Agency
PA	- Procurement Appropriation
PCA	- Physical Configuration Audit
PD	- Purchase Description
PDP	- Production and Deployment Phase
PM-MEP	- Project Manager, Mobile Electric Power
PMCS	- Preventive Maintenance checks and Service
POP	- Proof of Principle Phase
PPT	- Preproduction Test
PRR	- Production Readiness Review
R&D	- Research and Development
RAM-D	- Reliability, Availability, Maintainability, and Durability
ROC	- Required Operational Capability
SLEEP	- Signature Suppressed Lightweight Electric Energy Plants
SSP	- System Support Package
STB	- Super Tropical Bleach
STE-ICE	- Simplified Test Equipment-Internal Combustion Engine
T&E	- Test and Evaluation
TBD	- To Be Determined
TC	- Type Classification
TDP	- Technical Data Package
TECOM	- US Army Test and Evaluation Command
TEMP	- Test and Evaluation Master Plan
TFT&E	- Technical Feasibility Test and Evaluation
TIWG	- Test Integration Working Group
TMDE	- Test Measurement and Diagnostic Equipment
TRADOC	- US Army Training and Doctrine Command
TROSCOM	- US Army Troop Support Command
USAENS	- US Army Engineer School
USALEA	- US Army Logistics Evaluation Agency

APPENDIX D - DISTRIBUTION LIST

AGENCY	COPIES

To be developed at a later date.

APPENDIX I

PROCUREMENT ACQUISITION PLAN

PROCUREMENT ACQUISITION PLAN

10 KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

7 December 1987

Prepared For:

US ARMY
BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

FOREWORD

An Acquisition Plan (AP) is required following the guidance and format contained in AMC/TRADOC Pamphlet 70-2 dated 26 March 1987. A similar requirement exists for a Procurement Acquisition Plan (PAP) which stems from various Procurement Regulations. Because of the similarity of content of both plans, the Acquisition Plan has been incorporated into this document, the Procurement Acquisition Plan, verbatim or by reference.

TABLE OF CONTENTS

PART A. ACQUISITION BACKGROUND AND OBJECTIVES

1. Statement of Need. The Army established the requirement for a 10 kilo-Watt (kW) Signature Suppressed Lightweight Energy Plant (SLEEP) in an Operational and Organizational (O&O) Plan, dated 1 May 1985. Tactical units need a compact, mobile electric energy plant which is difficult to detect by aural and infrared (IR) methods. The 10kW SLEEP must be highly reliable and have a multifuel capability. It must produce electric power for command posts; command, control, communications, and intelligence (C^3I) systems; and maintenance, logistics, and other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units.

The 10kW SLEEP will be developed and procured through the Army Streamlined Acquisition Process (ASAP). This is the best materiel acquisition approach because the commercial sector does not manufacture power equipment to meet the Army's operational requirements. The program structure for the 10kW SLEEP is characterized by technical feasibility testing and evaluation during the Proof of Principle Phase (POP) and technical, user, and preproduction testing during the Development Proveout Phase (DPP). The 10kW SLEEP will be used in missions requiring high reliability and low signature.

The new generator set will be available in three modes: two Alternating Current (AC) modes, Mode II, 400 Hertz (Hz) and Mode III, 60 Hz; and one Direct Current (DC) mode, Mode IV. It will replace existing 10kW generator sets in nuclear capable delivery units and associated combat service support elements, signal units, air defense units, combat arms C^3I sections, and logistics functions in the brigade area. The 10kW SLEEP will be introduced through the supply system to prospective users with the nuclear capable delivery units and their associated combat service support elements holding priority. The basis of issue will be determined at a later date.

The capability to operate in forward areas necessitates improved combat effectiveness and unit survivability. Current Army generators are extremely

susceptible to aural and thermal IR detection because of their high signature profiles. Furthermore, excessive generator noise masks sounds which degrade the defender's ability to detect enemy movement. The 10kW SLEEP's improved reliability and low signature will reduce the potential of endangering personnel and equipment, increase a unit's mission performance capability, and reduce the need to operate combat vehicles as a source of electrical power within critical and sensitive areas.

2. Applicable Conditions.

a. Compatibility. The 10kW SLEEP will be fully interchangeable in form, fit, and function (F^3) with existing 10kW generator sets to include transportation requirements for those sets.

b. Constraints. There are no known constraints in cost, schedule, capability, or performance.

3. Cost. The draft Baseline Cost Estimate (BCE) dated 24 November 1987 was developed through the Life Cycle Cost Model (LCCM). The BCE contains the life cycle costs for 1,660 sets. The life cycle cost range of the SLEEP system is between $400M and $500M, based on the inherent cost estimating uncertainty of the funding implications determined from the Operational and Organizational (O&O) Plan.

The technology required for the 10kW SLEEP set to meet the signature suppression, size, weight, and survivability specifications is considered to be within the state-of-the-art. Therefore, the anticipated principal cost drivers are associated with component and technology integration. Specific cost and growth drivers will be developed at a later date.

a. Design-to-Cost. The 10kW SLEEP design will make maximum use of commercially available and military standard components. The 10kW SLEEP program will maintain a design-to-cost approach throughout development focusing on research and development, manufacturing, and operations and support. Cost goals will be established early in the program and addressed

at all In-Process Reviews (IPRs).

b. Should-Cost. The 10kW should-cost review will be conducted by an expert team with members having skills in manufacturing, management, buying, etc. The team will review procedures used by the contractor and determine where less costly methods might be employed. In general, the should-cost approach seeks to increase efficiency, decrease cost, and still provide a product of equal or better quality. The should-cost review will take place as the production contractor plans and implements the production line.

4. Capability or Performance. The performance characteristics of SLEEP are stated in the Purchase Description (PD). A performance characteristics summary related to the stated requirement follows:

a. Reliability, Availability, Maintainability, and Durability (RAM-D)

- o Operational Availability Rate (A_0) = 95%
- o Mean Time Between Operational Mission Failures (MTBOMF) = 600 hours.
- o Product Improvement Program (PIP) will be established in order to improve A_0.

b. Electric Performance

- o Electric Performance specifications for SLEEP are in MIL-STD-1332B.
- o SLEEP will produce rated power 15-25 minutes after start at temperatures above -25^{o}F and 25-30 minutes after start at or below -25^{o}F.
- o SLEEP will have a self-contained starter and starter power supply.
- o Starter power supply will be automatically recharged or regenerated when operating generator.

c. Aural Signature

- o The SLEEP set will emit no detectable aural signature at 100 meters. Non-detectability is defined by sound pressure levels

and octave bands contained in MIL-STD-1474.

d. Thermal Signature

- The thermal image of SLEEP will not be more than +/- 4°C from background temperature with over 90% of the surface exposed.
- Thermal image will be measurable from representative PAVE TACK type FLIR at 4000 meters.

e. Size and Weight

- The weight of SLEPP will be no more than 650 lbs.
- The size of SLEEP will be no more than 30 ft^3.

f. Fuel

- SLEEP shall have multifuel capability using fuels such as diesel, JP-4, 5 and 8 (kerosene) and synthetics.
- Fuel change will require no more than change of components by using unit personnel.

g. Climate

- Table 1-1 presents the design types and identifies a representative percentage of the Army 10kW SLEEP inventory operating in each climatic design type.

TABLE 1-1
CLIMATIC DESIGN

Climatic Design Types	Percentage of Inventory
Hot	15%
Basic	80%
Cold	Less than 5%
Severe	Less than 1%

- o SLEEP must operate in all climatic conditions from sea level to 8,000 feet.

- o SLEEP will produce 90% of rated power at 8,000 feet.

- o SLEEP will operate in hot, basic, cold, and severe cold conditions in accordance with AR 70-38.

h. Survivability

- o SLEEP must be Nuclear, Biological, and Chemical (NBC) contamination survivable.

- o SLEEP will have the same survivability as the units it supports in areas such as blast, fire, and NBC.

i. Operation and Maintenance

- o Operation and maintenance personnel requirements are the same as those required for current 10kW generator sets.

- o SLEEP will be capable of being operated and maintained by soldiers in arctic or Mission Oriented Protective Posture (MOPP) Level 4 chemical portective clothing.

j. Safety and Human Factors

- o MIL-STD-454 (Electronics), 1472 (Noise), 882 (Safety), 1474 (HFE) apply.

k. Transportability

- o SLEEP requires internal transport in C-130/141 and external transport on Army aircraft.

- o A properly configured 10kW SLEEP can withstand low velocity air drops and low altitude parachute extractions.

- o SLEEP requires the same towing and transport assets as current generator sets.

l. Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC)

- o EMI/EMC limits are listed in Requirement UM04 of MIL-STD-461.

5. Delivery. The production schedule and the First Unit Equipped Date (FUED) have not been established. This precludes the determination of a delivery schedule. However, once produced, the 10kW SLEEP will be introduced through the supply system to prospective users in accordance with the Department of the Army Master Priority List (DAMPL) sequence.

6. Trade-Offs. The 10kW SLEEP Acquisition Strategy emphasizes full and open competition during all phases of the acquisition process. This fact, together with low production quantities, tends to negate the need for production trade-offs to determine economical production rates.

7. Risks. The 10kW SLEEP program has been given a medium risk level due to unproven technology. Studies conducted by the Army and other agency development activities conclude that the proposed non-detectable power source is feasible and within the state-of-the-art for a number of advanced energy conversion technologies. The signature suppressed engine, generator, and all other key components are currently not commercially available.

8. Applicability of Decision Coordinating Paper (DCP). The IPR package prepared for a combined Milestone Decision Review II/III will contain a DCP.

9. Approval for Operational Use. Approval for operational use will be obtained in conjunction with the approved User Test (UT) Report and a successful Milestone Decision Review II/III decision.

PART B. PLAN OF ACTION

1. Sources. An Engine-Generator Set data base, developed with contractor support, includes information on all US military standard equipment, and almost 950 commercial products from 61 firms in 14 free-world countries. During 3 June 1987 to 14 January 1988, this data base was used to generate information on commercial generators and direct contact with research and development firms for information on new technology.

2. Competition. The Total Life Cycle Competition Strategy (TLCCS) for 10kW SLEEP is built upon full and open competition. The type of contracts used in each phase will depend on the technical risks associated with end item development for that phase.

Developing SLEEP hardware incurs a medium technical risk. Consequently, cost-reimbursement contracts will be used for development of 10kW SLEEP sets. If required, the initial contractor provisioning for spares, repair parts, and components for the end item will be included in the solicitation document. However, initial provisioning will be priced separately from the end item and will become an item for negotiation with the contractor. If Interim Contractor Support (ICS) is needed to reinforce normal maintenance channels, it will also be priced and negotiated separately with the contractor for a specified time period. The Government will normally provide maintenance and overhaul; however, if contractor maintenance is required to support the end item, the contract will be competed.

3. Source-Selection Process. End item procurement will be competed through Requests for Proposals (RFPs) advertised in the Commerce Business Daily. The RFPs will normally consist of three components: technical, management, and cost. Technical considerations will be rated above those of management. An award may be made to an acceptable offer with technical advantages sufficient to justify the payment of additional monies.

The technical response to the RFP will provide the basis of the company's ability to build the 10kW SLEEP. The management proposal will show the company's ability to perform, and its approach to providing competitive sources of supply for repair parts. The cost proposal will be used in conjunction with the technical and management evaluations described above. The RFP process will also provide a vehicle for best and final offers.

All qualified manufacturers will be allowed to compete for the production contracts. Small business firms or other related set-asides will be emphasized and used as appropriate. Based on a source selection process,

the award will be made to the manufacturers who best meet the terms of the RFP, are determined reliable and technically qualified to successfully produce the equipment, and are competitive in cost.

4. Contracting Considerations. Competitively awarded Cost Plus Fixed Fee (CPFF) contracts are planned during POP for two prototype systems of each generator mode. These prototypes will be used for the Technical Feasibility Test and Evaluation (TFT&E). Upon successful testing and a positive Milestone Decision Review II/III decision, multiple CPFF engineering development contracts will be competitively awarded. The prototypes will undergo exhaustive tests during development and operational testing, and actually participate in a "shoot-off" during the process. Any of the manufacturers that passed the test criteria and met the operational requirements will be selected to compete for the preproduction contracts.

The objective is to have at least two manufacturers for each generator mode competing for the preproduction contracts. These contracts include development of technical data packages (TDPs) and Level 3 Drawings. US Army Troop Support Command (TROSCOM) will develop the RFP for a Firm Fixed Price (FFP) contract and assume responsibility for the procurement, production, and readiness of the end item. The contractors are expected to provide standard manufacturer warranty coverage for the end item and its major components or assemblies. Although the breakout of components and spares will be determined at a later date, contractor support may be required to provide the initial provisioning and spare parts for the equipment. It is anticipated that this type of contractor support would be priced out separately from the end item.

5. Budgeting and Funding. The anticipated principal cost drivers are expected to be components and new technology integration. Specific cost drivers will be the "design target" indicated in the PD, such as size of 30 cubic feet, weight of 650 pounds, aural non-detectability of 100 meters, thermal non-detectability of 4000 meters, NBC survivability, and RAM-D criteria. Other cost drivers are associated with new equipment training (NET). The overall cost and growth of the program will be constrained by

the competitively awarded production contract with annual economic price adjustments to compensate for inflation.

6. Product Description. The 10kW SLEEP will be a lightweight tactical multi-fueled generator difficult to detect by aural and IR methods. The set shall be a housed unit consisting of a brushless generator, excitation system, governing system, fuel system, 24 DC volt cranking system, control system, and protection system.

7. Priorities, Allocations and Allotments. None have been invoked.

8. Contractor versus Government Performance. The US Army Engineer School (USAENS) has been designated as the combat developer and proponent school by the US Army Training and Doctrine Command (TRADOC). A total contractor managed approach is not appropriate for this equipment because the 10kW SLEEP technology selection and implementation process will require numerous Government decisions and interactions with the contractor team. In addition, equipment development may require several contractors.

9. Management Information Requirements. All contract efforts are monitored with monthly progress and cost reports, periodic on-site visits, and progress/status meetings, as appropriate.

10. Make or Buy. When economically feasible, the production contractor will buy certain components from subcontractors rather than produce them. Items which will be purchased are: solid state components and subassemblies, switches, terminals, gauges, and wiring. The prime contractor will reveal how subcontractors are selected and which SLEEP components will be acquired from subcontractors.

11. Test and Evaluation. A Test and Evaluation Master Plan (TEMP) will be developed for Milestone Decision Review I. The TEMP will center on a three-phase research, development, and procurement process. Testing during each phase is as follows:

(a) Proof of Principle Phase (POP). The objective of POP is to develop a system with effectively suppressed aural and IR battlefield signatures and a reliability greater than the current 10kW generator sets. During this phase there will be a TFT&E which will consist of two parts, technical and user demonstrations. The TFT&E prototypes will be the least complex of the prototypes developed. These prototypes will be exploratory systems designed to demonstrate the concept and technology available.

(1) Technical Demonstration. Concepts and components will be demonstrated using brassboard prototypes and/or surrogate components or systems.

(2) User Demonstration. Representative user troops will be provided with a brassboard prototype of the 10kW SLEEP generator set. These troops will operate and maintain the generator set in accordance with (IAW) the approved Operational and Organizational (O&O) Plan. The test environments will be representative of those proposed for 10kW SLEEP operations.

(b) Development and Proveout Phase (DPP). The objective of DPP is to design a comprehensive 10kW SLEEP generator system. Testing of the prototype 10kW SLEEP systems will be conducted and reports developed prior to Milestone Decision Review II/III Type Classification (TC).

(1) Technical Test. Testing will assess the signature suppression effectiveness; achievement of reliability goals; high altitude electromagnetic pulse (HAEMP) survivability; construction; voltage and frequency adjustment and quality; non-interference and susceptibility; and interoperability of the 10kW SLEEP systems. The prototypes used in this test will incorporate advance technologies and permit the integration of newly proven technologies.

(2) User Test. Testing will be conducted in an environment which approximates the proposed operational environments for 10kW SLEEP. Particular attention will be directed towards the requirements for the end users, adequacy of documentation, training requirements, battlefield signature, NBC

operations, contamination/decontamination survivability, and logistical requirements.

(3) Preproduction Test (PPT). Initial production operational concerns will be evaluated to ensure that the 10kW SLEEP generator sets can be manufactured cost effectively and IAW the PD and that the new system does meets operational requirements. Funds for the hard-tooled prototypes and the testing may be obtained from the Procurement Appropriation (PA). The initiation of PA funded activities will require that an IPR be conducted to approve the action. PA funded activities could include: Initial Production Facilitization (IPF), Long Lead Time Items (LLTI), development of hard-tooled prototypes, and the conduct of a Production Readiness Review (PRR).

(c) Production and Deployment Phase (PDP). Product Acceptance Testing will be conducted during this phase and will be composed of three parts: Final Functional Configuration Audit (FCA), First Article Test (FAT), and Final Physical Configuration Audit (PCA). The Final FCA will validate the attainment of performance specifications; the FAT will verify the acceptability of each 10kW SLEEP type; and the Final PCA will examine the full production tooling of the manufacturers. All test dates have yet to be determined.

12. Logistics Considerations. The design and development process for the 10kW SLEEP must consider Integrated Logistics Support (ILS) to ensure properly supported equipment before and after fielding. All design decisions will be evaluated to determine their impact on ILS so that support requirements can be identified and accommodated. TROSCOM is responsible for ILS and will prepare an Integrated Logistics Support Plan (ILSP) to document the program and fully address total system support requirements.

a. The 10kW SLEEP set will be supported through the standard Army logistics system. The spares, repair parts, and components will be available through normal supply channels. However, interim contractor support may be required until the equipment can be fully supported by the Army's logistics system. Establishing a Mandatory Parts List (MPL) that

will provide sufficient essential repair parts at the unit level will be considered. The overall maintenance concept and requirements for transportability, packaging, handling, and storage will be built around the programs established for the current 10kW generator set. Any new or additional requirements, such as the security that may be needed for the 10kW SLEEP components and assemblies while in storage, will be addressed as the program develops. New facilities will not be required for this program.

b. In an effort to assist in the logistic support and lower the potential for problems in the field, the 10kW SLEEP will incorporate a modular design with easily replaceable components and built-in-test-equipment (BITE). The use of tools, test equipment, and other support items currently authorized for current generator sets will be maximized. Special tools and equipment will be minimized. A System Support Package (SSP) will be prepared by the US Army Belvoir Research, Development and Engineering Center (BELVOIR) and validated during TT and UT. A requirement for the SSP will be included in the production contractor's Statement of Work (SOW). Technical data, to include the TDP; and any new Test, Measurement, and Diagnostic Equipment (TMDE); NET; and Depot Maintenance Work Requirements (DMWR) will also be procured through the production contract. Contractors will support all testing and provide commercial support literature with the equipment. The need for technical manuals will be addressed when TROSCOM develops the ILSP. Options include converting commercial technical and support literature into the military format and style and developing a new technical manual.

c. The Basis of Issue Plan (BOIP) which lists quantities, support equipment, personnel changes, and the Quantitative and Qualitative Personnel Requirements Information (QQPRI) which identifies operator and maintenance skills, will be initiated at a later date. The 10kW SLEEP set will not require additional personnel or a new Military Occupational Specialty (MOS). The introduction of SLEEP technology could require special maintenance methods and procedures which may require some new skills. The use of an Additional Skill Identifier (ASI) for generator maintenance personnel will be considered at a later date. Institutional training should be minimal.

NET will be required for instructors and key personnel prior to UT and PPT and to support the initial fielding of the equipment. The BOIP and QQPRI will confirm the personnel and skill training requirements for the program. The specific requirements then will be included in the ILSP.

13. Reliability, Maintainability, and Quality Assurance Objectives, including Warranties.

a. Specifications and Requirements.

(1) The reliability of the set is specified at 600 MBTOMF.

(2) The set shall have a minimum life of no less than 12,000 hours. Set overhaul (excluding engine) shall be allowed at no less than 6,000 hours intervals. Overhaul of the engine shall be allowed at no less than 3,000 hour intervals. Replacement of the engine, major engine components, or generator shall not be allowed during overhaul. The set, after overhaul, shall be capable of meeting all requirements.

(3) The maintenance ratio of the set shall not exceed 0.05. All scheduled maintenance at intervals less than 1000 hours shall require a maximum of two hours to perform with one mechanic (MOS-52D). Unscheduled maintenance shall be kept to a maximum of two hours when practical.

- The minimum interval between scheduled maintenance shall be 12 hours. Except for scheduled maintenance preventative checks and inspections the time between schedule maintenance service (repair, adjustment, service, and replacement) shall not be less than 250 hours. Injectors, if used, shall not require scheduled maintenance at intervals less than 1000 hours. One person (MOS-52D) shall be able to change the oil and oil filter within 20 minutes. A means to quickly and easily check and add coolant while the set is off shall be provided. A means to quickly and easily check and add oil while the set is running or off shall be provided. A means to bleed the fuel system of air or water with the set running or off shall be provided. The time needed to service and checkout the set, from shutdown to resumption of power generation, will be a maximum of 30 minutes with a maximum reaction time of 30 minutes at temperatures below -25^{o}F and 15 minutes at temperatures at or above-

25°F.

- Test, Measurement, and Diagnostic Equipment (TMDE) required for maintenance shall currently exist in the supply system. When required, as much TMDE as practical shall be selected from the TMDE Preferred Items List (DA Pamphlet No. 700-21-1). Sets shall be equipped with a diagnostic connector assembly (DCA) to allow for maintenance interface with the Simplified Test Equipment Internal Combustion Engine (STE-ICE) TMDE. Hydraulic systems shall be designed so all required maintenance can be accomplished with the Hydraulic System Test and Repair Unit (HSTRU). Standard tools in the General Mechanic's Automotive Tool Kit (SC 5180-90-CL-N26-HR; NSN 5180-00-177-7033; LIN W33004) shall be used as much as possible for set maintenance.

(4) The warranty program for 10kW SLEEP set and its major components and assemblies will be specified in each contractor's SOW. Warranty coverage will include, but not be limited to, workmanship and material defects, performance capabilities, and reliability, availability, maintainability, and durability (RAM-D) objectives.

b. Design Disciplines. The 10kW SLEEP mission profile was established by the Army in requirements documents and will be considered in development specifications, parts programs, and the corrosion prevention and control program plan to be established.

c. Test Program.

(1) Preproduction models will be examined and tested to determine compliance with reliability and maintainability (R&M) specifications contained in the PD.

(2) Quality performance inspections and tests will be conducted to determine conformance to the PD and drawings. Generator tests will be conducted prior to assembly into the set. Test procedures will include instrumentation, audio noise, railroad impact, drop, EMI, air transportability, motor starting, humidity, road, and salt fog tests.

(3) A reliability/endurance/maintainability (REM) test will be conducted on two sets of each mode. Data will be analyzed in accordance with requirements specified in the PD. The REM test shall be performed in accordance with method 695.1 of MIL-STD-705.

d. Controls and Reporting. Unless otherwise specified, the contractor will be responsible for the performance of all inspections and tests. Unless disapproved by the Government or otherwise specified in the PD or the contract, the contractor may use his own or any other facilities suitable for the performance of inspections and tests. The Government reserves the right to perform or repeat any of the inspections/tests set forth in this purchase description where such inspections/tests are deemed necessary to assure supplies and services conform to prescribed requirements.

(1) Failure of any inspection or test by the preproduction model generator, generator with excitation system, or generator sets shall be cause for disassembly, in the presence of a Government representative, to the extent necessary to determine the cause of the failure. Each disassembled part shall be examined in detail for compliance with the PD. Parts not complying with requirements shall be rejected and shall be cause for rejection of the preproduction model set. Reassembly with acceptable components or parts and reinspection/retest shall be the responsibility of the contractor.

(2) Should the Government elect to perform or repeat any inspection or test in the PD, failure of a set to meet any requirement specified therein shall be cause for refusal by the Government to accept production sets until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiencies. Correction of such deficiencies shall be accomplished by the contractor at no cost to the Government on sets previously produced under the contract. Any deficiencies found as the result of such elective inspection/test will be considered prima facie evidence that all sets accepted prior to the completion of such inspection/tests are similarly deficient unless evidence to the contrary is furnished by the contractor and such evidence is

acceptable to the contracting officer. These provisions apply, notwithstanding any prior acceptance of preproduction model sets, preproduction model test reports, or initial production sets.

e. Quality Assurance. The quality assurance program will comply with MIL-Q-9858.

14. Government-Furnished Property. Government-Furnished Property, except as detailed in this document, shall be determined at a later date.

15. Government-Furnished information. No Government-furnished information has been identified.

16. Environmental Considerations. Based on conclusions from a draft Environmental Assessment Plan dated 20 November 1987 there are no significant environmental impacts anticipated during the life cycle of the proposed 10kW SLEEP.

17. Security Considerations. No security considerations are involved with SLEEP.

18. Safety Considerations. The 10kW SLEEP must conform to applicable health and safety requirements and accepted human factors criteria. In order to meet this objective, safety and health issues must be addressed at all stages of development and testing. Safety hazards that are identified will be eliminated or controlled to acceptable levels as per MIL-STD-882B.

19. Other Considerations.

a. Energy Conservation. The overall efficiency of the 10kW SLEEP will be greater than current generators of the same power rating.

b. Industrial Readiness Program/Defense Production Act. There is little or no impact on industrial readiness or production since SLEEP is relatively small, uses no strategic materials, and can be manufactured at a

large number of facilities. SLEEP lends itself to subcontractor manufacture of a number of its subassemblies which can then be integrated into the main assembly by the contractor.

c. Foreign Sales. The other services and allies have shown little interest in the development and acquisition of the 10kW SLEEP sets. However, Australia, Great Britain, Canada, and other NATO forces are pursuing other signature suppressed generators and are closely monitoring the development of US technologies. The exchange of signature suppression data and program information will be conducted by the Project Manager for Mobile Electric Power (PM-MEP).

20. Milestones for the Acquisition Schedule. The 10kW SLEEP acquisition program is currently in the Requirements/Technical Base Activities Phase of ASAP. The project is not defined to the point where all program milestones have been determined. The milestone schedule at Appendix A includes significant procurement and testing milestones that are currently being developed.

21. Identification of Participants. See Appendix B for a list of personnel associated with SLEEP procurement.

APPENDIX A

MILESTONE SCHEDULE

ACTIVITIES AND EVENTS	DURATION ONCE INITIATED
Program Initiation	
Requirements and Technology Base Activity	
Materiel Acquisition Review Board (MARB)	
Proof of Principle Phase (POP)	1-2 Years
Market Investigation	3 Months*
Verify Design and Engineering	3 Months*
Functional Purchase Description (PD)	6 Months*
Prototype Components/System	12 Months
Technical Demonstration	3 Months
Troop Demonstration	3 Months
Milestone I/II In-Process Review (IPR) (Go - No Go)	
Development and Production Proveout (DPP)	4 Years
Prototype System	18 Months
Technical Test and Evaluation	6 Months
User Test and Evaluation	6 Months
PD	6 Months*
Complete Technical Data Package (TDP)	6 Months*
Procurement Appropriation (PA) Initiation IPR	
Initial Production Facilitization (IPF)	6 Months*
Procure Long Lead Time Items (LLTI)	1 Month *
Preproduction Test (PPT) (Hard-Tooled Prototypes)	6 Months
Production Readiness Review (PRR)	1 Month
Production Solicitation Document Developed	6 Months*
Milestone II/III Type Classification (TC) IPR	
Production and Deployment Phase (PDP)	
Product Acceptance Test	
First Article Test (FAT)	
First Unit Equipped (FUE) (Materiel Release)	
Initial Operational Capability (IOC)	

NOTES:

1. A * indicates events that can be scheduled concurrently during the POP and DPP.

2. The streamlined approach is based on mature technology and low risk, which are confirmed by technical reports, engineering analysis, and/or Market Investigation. The Milestone I/II IPR will decide on continued research or advancing the program to the next phase.

APPENDIX B

DISTRIBUTION LIST

PRINCIPLE MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE	TELEPHONE
PROJECT MANAGER	PM-MOBILE ELECTRIC POWER 7500 Backlick Road Springfield, Virginia 22150-3107	____________	(703)355-3757
PROCURING AGENCY	COMMANDER US ARMY TROOP SUPPORT COMMAND ATTN: AMSTR-STP ATTN: AMSTR-LIB 4300 Goodfellow Blvd. St. Louis, Missouri 63120	____________	____________
MATERIEL DEVELOPER	US ARMY BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER ATTN: STRBE-FG Fort Belvoir, Virginia 22060-5606	____________	____________
COMBAT DEVELOPER	COMMANDER US ARMY ENGINEER CENTER AND SCHOOL ATTN: ATZA-CDM Fort Belvoir, Virginia 22060	____________	____________
OPERATIONAL TESTER	US ARMY TRAINING AND DOCTRINE COMMAND ATTN: ATZA-TSM-G Fort Belvoir, Virginia 22060-5606	____________	____________
OPERATIONAL TEST EVALUATOR	COMMANDER US ARMY COMBINED ARMS CENTER ATTN: ATZL-TIE Fort Leavenworth, Kansas 66027	____________	____________

DISTRIBUTION LIST (cont.)

PRINCIPLE MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE	TELEPHONE
TECHNICAL TESTER	COMMANDER US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTS-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005		
LOGISTICIAN	COMMANDANT US ARMY LOGISTICS EVALUATION AGENCY ATTN: DALO-LEA New Cumberland, PA 17070		
USER REPRESENTATIVE	COMMANDER US ARMY ENGINEER CENTER AND SCHOOL ATTN: ATZA-CDM Fort Belvoir, Virginia 22060		
TECHNICAL DEMONSTRATION CONDUCTOR	US ARMY BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER ATTN: STRBE-FG Fort Belvoir, Virginia 22060-5606/		
	CONTRACTOR		
TECHNICAL DEMONSTRATION INDEPENDENT EVALUATOR	US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTE-TE-T Aberdeen Proving Gound Aberdeen, Maryland 21005-5201		
TROOP DEMONSTRATION CONDUCTOR	COMMANDER US ARMY ENGINEER CENTER AND SCHOOL ATTN: ATZA-CDM Fort Belvoir, Virginia 22060		

DISTRIBUTION LIST (cont.)

PRINCIPLE MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE	TELEPHONE
TROOP DEMONSTRATION INDEPENDENT EVALUATOR	COMMANDER US ARMY TRAINING AND DOCTRINE COMMAND COMBINED ARMS CENTER Fort Leavenworth, Kansas 66027	____________	(913)684-5621
TECHNICAL TEST INDEPENDENT EVALUATOR	COMMANDER US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTS-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005	____________	____________
USER TESTER	COMMANDER US ARMY OPERATIONAL TEST AND EVALUATION AGENCY ATTN: CSTE-CSN ATTN: CSTE-PON 5600 Columbia Pike Falls Church, Virginia 22041	____________	____________
USER TEST INDEPENDENT EVALUATOR	US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTE-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005-5201	____________	____________
PRE-PRODUCTION TESTER	COMMANDER US ARMY OPERATIONAL TEST AND EVALUATION AGENCY ATTN: CSTE-CSN ATTN: CSTE-PON 5600 Columbia Pike Falls Church, Virginia 22041	____________	____________
PRE-PRODUCTION TEST INDEPENDENT EVALUATOR	US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTE-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005-5201	____________	____________

DISTRIBUTION LIST (cont.)

PRINCIPLE MEMBER	COMMANDER'S NAME OFFICE AND AGENCY	REPRESENTATIVE	TELEPHONE
PRODUCT ACCEPTANCE TESTER	COMMANDER US ARMY TEST AND EVALUATION COMMAND ATTN: AMSTS-TE-T Aberdeen Proving Grounds Aberdeen, Maryland 21005	____________	____________
PRODUCT ACCEPTANCE TEST INDEPENDENT EVALUATOR	COMMANDER US ARMY OPERATIONAL TEST AND EVALUATION AGENCY ATTN: CSTE-CSN ATTN: CSTE-PON 5600 Columbia Pike Falls Church, Virginia 22041	____________	____________
TRAINER	COMMANDER US ARMY ENGINEER CENTER AND SCHOOL ATTN: ATZA-CDM Fort Belvoir, Virginia 22060	____________	____________

APPENDIX J

ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL ASSESSMENT

10KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

20 November 1987

Prepared For:

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

DEPARTMENT OF THE ARMY
US ARMY BELVOIR
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ENVIRONMENTAL ASSESSMENT

10KW SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT (SLEEP)

20 NOVEMBER 1987

Prepared By:

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ENVIRONMENTAL ASSESSMENT

10KW SIGNATURE SUPPRESSED
LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

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DEPARTMENT OF THE ARMY

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ENVIRONMENTAL ASSESSMENT
10KW SIGNATURE SUPPRESSED
LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

A. PURPOSE AND NEED FOR THE PROPOSED ACTION

The Army has established an operational requirement for the development of a 10 kilowatt (kW) Signature Suppressed Lightweight Energy Plant (SLEEP). Tactical units need a compact, mobile electric energy plant which is difficult to detect by aural and infrared (IR) methods. The 10kW SLEEP set must be highly reliable and have a multi-fuel capability. It must produce electric power for command posts; command, control, communications, and intelligence (C^3I) systems; maintenance and logistics functions; and other support activities where high reliability, mobility, and signature suppression are essential to mission performance and survivability of the supported units. Current Army generators are extremely susceptible to aural and thermal detection because of their high signature profiles. Furthermore, excessive generator noise degrades the defender's ability to detect intruders and enemy movement. The 10kW SLEEP set with improved reliability and low signatures will reduce the potential of endangering personnel and equipment, increase a unit's mission performance capability, reduce the need to operate combat vehicles as a source of electrical power within critical and sensitive areas,improve unit concealment, and reduce vehicle wear.

B. DESCRIPTION OF THE 10KW SLEEP

1. General. The set shall be a housed unit consisting of: a brushless generator, excitation system, governing system, fuel system, 24 dc volt

cranking system, control system, protection system, and an engine that can operate on the fuels specified below.

2. Fuels. The set shall operate using diesel fuel which conforms to MIL-F-46162 or DF-1, DF-2, or DF-A; diesel fuel conforming to VV-F-800; or JP-8 turbine fuel conforming to MIL-T-83133. The set shall meet all specified requirements while operating on JP-4 turbine fuel conforming to MIL-T-5624 with a cetane rating of 30 to 35. However, rated load may be reduced 15 percent, at which time a maximum of 300 hours of operation on JP-4 per 3,000 hours of set operation shall be required.

3. Lubricants. The set shall operate on engine lubricating oil conforming to MIL-L-2104 and MIL-L-46167.

4. Hydraulic Fluids. If hydraulic fluid is required, the set shall be capable of operating with MIL-H-5606 and MIL-H-6083 hydraulic fluid.

5. Coolant. If the set includes a liquid-cooled engine, the engine shall be capable of operating with the following coolants:

a. Diluted MIL-A-11755 anti-freeze from -50 ^{o}F to 120 ^{o}F ambient.

b. Water with O-A-548 anti-freeze or MIL-A-46153 inhibited anti-freeze from -40 ^{o}F to 120 ^{o}F ambient.

c. Water with O-I-490 inhibitor from 40 ^{o}F to 120 ^{o}F ambient.

6. Engine Lubricating System. The lubricating system shall include seals, gaskets, and bearing clearances to permit use of arctic lubricating oil conforming to MIL-L-46167. The lubricating system shall be compatible with MIL-L-21260 preservative oil. Oil temperature in the oil sump shall stabilize between 100^{o}F and 250^{o}F under all expected operating conditions. An oil-drain assembly, consisting of flexible hose assembly and shut-off valve, shall be installed to allow complete drainage of the crankcase/oil-sump outside of the skid base into a suitable container. The oil-drain opening shall have sufficient depth to permit seating of a flexible hose assembly pipe fitting in accordance

with SAE standards. Piping, valves, fittings, and tubing of the lubricating system shall have the ability to be disconnected from each other and easily accessible for maintenance. The oil filler opening shall permit oil filling from a standard gallon can conforming to ANSI MH 3.1 clearances. The oil-level bayonet gage shall be marked to accurately indicate full and low oil levels, with the set in a level position while engine is stopped. The bayonet gage shall be placed in a readily accessible location and shall be installed so that no oil leakage occurs under all expected operating conditions. The volume of oil indicated between the "LOW" and "FULL" marks on the dipstick (bayonet gage) shall be sufficient to permit a minimum of 24 hours of operation without requiring the addition of oil. A captive filler cap shall be provided except in the case where the cap and dipstick are of an integral design. The engine shall operate in planes from level to 15 degrees from level and with the oil level at the "LOW" mark on the dipstick when measured with the set in a level position. A full flow oil filtration system shall be provided. Marking shall be provided at the fill port and oil drain in accordance with MIL-STD-1472 (5.9.5).

7. Material Deterioration and Control. Sets shall be fabricated from compatible metals and materials that are inherently corrosion resistant or are treated to prevent corrosion and deterioration associated with storage and expected operating environments.

a. The specific material, material finish, or treatment for use with components and sub-assemblies shall be identified. This information shall be provided to the Government upon request.

b. Dissimilar metals shall not be used in intimate contact with each other unless protected against galvanic corrosion. Dissimilar metals and methods of protection are defined and detailed in MIL-STD-889. The identification of the specific material, material finish, or treatment used for any component or sub-component shall be made available, upon request, to the Government.

8. Toxic Products. When possible, nontoxic material shall be chosen. When not possible, the toxic materials contained within the set shall be controlled to present no hazard to operator or maintenance personnel under any condition. Material safety shall be in accordance with FED-STD-313.

9. Thermal and sound insulating material. Thermal and sound insulating material shall be: free from perceptible odors and noxious fumes; fire retardant (flame spread classification of 25 or less by ASTM E 84); unaffected by battery electrolyte or petroleum derivatives; and capable of maintaining its shape, position, and consistency inherently with suitable retaining methods.

10. Recovered Materials. For this requirement, recovered materials (as distinguished from virgin materials) are defined as materials collected from solid waste and reprocessed to become a source of raw materials. The components, pieces, and parts incorporated in the set may be newly fabricated from recovered materials to the maximum extent practical, provided the materials, components, and end item meet all other requirements. Used, rebuilt, or remanufactured components, pieces, or parts shall not be incorporated in the set.

11. Audio noise. The set shall meet the standards for aural non-detectability of steady state noise at a nominal distance of 100 meters from the set, as defined by Sound Pressure Levels (SPLs) and respective Octave Bands prescribed by MIL-STD-1474. For hearing protection of friendly personnel working on or near the set, the set shall not emit noise levels in excess of those described in Category D of MIL-STD-1474.

12. Exhaust system. The exhaust system shall have a spark arresting capability in compliance with Forest Service Standard 5100-1a. Exhaust gases after discharge shall not re-enter the set. A means of preventing rain from entering the exhaust system shall be provided.

13. Fuel tank. A fuel tank shall be located within the set housing. It shall be located in a manner which will not allow spills or overflows to run into the engine, exhaust, or electrical equipment. It shall be readily removable from the set. Plastic threads shall not be used for fuel line connections. The fuel tank capacity shall enable eight hour continuous operation at rated output on all specified fuels when the skid base is level. A fuel shield shall be positioned to prevent spillage of fuel onto the set during filling. Filling shall not require the opening of any door. The set shall be constructed to permit filling the tank and operation of the set when the set is inclined from level to 15 degrees from level. A fuel drain and drain valve will allow the emptying of any fuel and tank sediment into a container without requiring tank removal. The fuel drain shall terminate with a brass, external thread, 1/2 - 20 SAE J514 flared fitting, with captive cap in accordance with DOD Drawing No. 69-539-2. All fuel shall drain outside of the skid base. The inlet of the fuel pickup shall be not less than 1/2-inch from the bottom of the fuel tank and the inlet end of the fuel pickup shall be cut off at an angle or v-shape. The fuel filler shall be positioned to allow filling the tank from a 5 gallon fuel can. The fuel neck opening shall be 3 9/16 inches diameter. The fuel filler shall have a removable fuel strainer attached to the filler with a chain of sufficient length to permit removal for cleaning. The fuel cap shall be vented. The tank and fuel system shall meet all anticipated transport and handling requirements.

14. Housing. The set housing shall be removable. It shall prevent wind-driven rain, snow, and sleet from entering the set interior. The set housing shall be removable to perform maintenance actions, including overhaul, requiring removal of the engine, generator, and other components. The housing shall have access doors as necessary for maintenance and shall support 200 pounds per square foot (psf) at any point on the top without permanent deformation. Housing doors shall be self supporting in the open position.

15. Skid base. The skid base shall extend beyond any component of the set. The skid base shall be provided with a method to drain spilled liquids from the interior of the set. There shall be at least a two-inch clearance between the lowest projection of the set and the bottom of the skid base. The set shall not move while operating unrestrained, on a level concrete surface, under all specified operating conditions.

16. Smoke limits. The set engine shall operate under all conditions at all set loads with a smoke reading of not more than 4.0 when measured and analyzed. Overload and transient conditions are excluded.

17. Fuel consumption. The rated load fuel consumption shall not exceed 0.09 gallon per kilowatt hour.

18. Physical Configuration.

a. Size. The overall dimensions of an operating set shall not exceed 30.0 cubic feet.

b. Weight. The set dry weight shall not exceed 650 pounds.

C. ALTERNATIVES CONSIDERED TO SATISFY THE NEED AND THEIR ENVIRONMENTAL IMPACT

All viable alternatives considered to meet the requirement for this 10kW SLEEP exhibit similar environmental impacts.

D. ENVIRONMENTAL IMPACTS OF THE PROPOSED PROJECT

1. First Article Fabrication and Testing Phase

a. Affected Environment

(1) Fabrication. The 10kW SLEEP will contain new technology or extend existing technology to the state-of-the-art. The

engine, generator, and all other components are not commercially available. Fabrication of the generator set from components will involve commercially standard sheet metal, machining, welding, soldering, wiring, piping, and painting processes. Since no environmentally hazardous substances are planned to be used, none of these processes or components have been identified to have a significant environmental impact.

(2) Testing. The 10kW SLEEP will be subjected to a variety of operational and non-operational tests in accordance with its Purchase Description. Operation of the equipment will add unique exhaust emission and heat to the atmosphere, increase the local noise level, and increase the risk of fuel spillage. These tests will be conducted at both Government owned and contractor test sites.

The tests will show that the 10kW SLEEP is capable of continuous operation ranging from intermittent short periods to extended periods up to approximately 360 hours without shutdown. It is designed to operate satisfactorily at full load at all prescribed altitudes under all types of climatic conditions, ranging from arctic cold to desert heat, high temperature and high humidity. It is designed to withstand transportation over rough terrain during cross-country travel. When properly preserved, packaged, and mechanically protected, it should be capable of starting and operating after storage over prolonged periods.

b. Direct and Indirect Impacts

(1) Design criteria for the engine specify that the rated fuel consumption shall not exceed 0.09 gallon per kilowatt hour. Engine exhaust emissions are not expected to contribute significantly to atmospheric pollution.

(2) Care will be taken to ensure that no fuel will be spilled on the soil during testing due to carelessness during refueling or due to a leak in the fuel tank. If spillage occurs in sufficient quantity, the soil in the vicinity of the generator set could be contaminated. The quantities of fuel handled in refueling will not be large enough for catastrophic spills or failures and will not result in the destruction of any appreciable amount of ground vegetation, aquatic organisms, or contamination of surface and ground water drinking sources. No secondary effects upon the environment are anticipated.

(3) The heat discharged by the engine exhaust and cooling systems to the atmosphere at full load will be insignificant for each set. It is not anticipated that this heat loading will cause any significant thermal disturbance to the surrounding environment.

(4) There are no current or proposed EPA or known state/local noise pollution standards for diesel powered electrical generating plants (Reference 1). The only known standards relate to occupational safety of operators, not noise emissions to the surrounding environment. The OSHA standard requires ear protection whenever the noise level exceeds 85 decibels.

c. Adverse Effects and/or Conflicts Which Cannot be Avoided. The discharge of diesel exhaust emissions, thermal heat, and noise to the environment cannot be avoided. The quantities of these emissions from the generator sets involved during testing are not expected to result in any direct irreversible environmental damage.

2. Production/Deployment Phase. The Basis of Issue Plan (BOIP) for the 10kW SLEEP is yet to be developed. The intention is to procure the sets on a one-for-one replacement for future procurement of 10kW

generator sets in nuclear capable delivery units, combat support, and combat service support organizations in the brigade area.

a. Affected Environments. The engine, generator and other components and materials used in fabricating the 10kW SLEEP are manufactured using standard commercial practices. No unique or additional pollutants should be generated in the manufacture of the proposed hardware. Full usage of these sets would occur only during combat situations under which potential environmental impacts or effects become secondary to success of the wartime mission. However, even under such conditions, contamination of the soil and ground water should be avoided by proper operator training and implementation of sound operational practices.

b. Direct and Indirect Impacts. Direct impacts during deployment are potential contamination of the soil and atmosphere. However, since the deployed 10kW SLEEP requires periodic maintenance checks and inspections, early detection of potential fuel spill situations is expected and the problem should therefore be quickly corrected.

c. Adverse Effects and/or Conflicts Which Cannot be Avoided. The emission of diesel engine exhaust gases and thermal energy into the atmosphere cannot be avoided. However, the number of sets involved, the amount of emissions from each set, the world wide distribution, and intermittent operation (stand-by and combat deployment) combine to minimize the potential for environmental insult and damage. With proper training and exercise of care and caution by operating personnel, potential soil contamination during fuel handling will also be greatly reduced.

d. Recommended Mitigation. Appropriate precaution will be exercised by the deployed 10kW SLEEP operating personnel through proper training, certification, operating procedures, maintenance inspections, and immediate response to repair detected leaks. Proper locations of the generator sets with relation to the

activities being serviced will also lessen the effects of noise and air pollution due to emitted exhaust gases and heat.

3. Disposal Phase. The useful service life of the 10 kW SLEEP is estimated to be between 5 and 10 years.

a. Affected Environments. Disposal of the generator sets at termination of their useful life will have a minimal effect on the environment since there are no known toxic or hazardous materials involved. The primary materials anticipated at disposal are steel, copper, and aluminum.

b. Direct and Indirect Impacts. The direct impact will be scrap steel and copper for potential recycling. The only indirect impact may occur from draining of the fuel and lubricating oil tanks when the set is dismantled. This is a routine operation and with proper precaution, there should be no direct or indirect impact upon the surrounding environment.

c. Adverse Effects and/or Conflicts Which Cannot be Avoided. There are no expected adverse effects and/or conflicts which cannot be avoided during the disposal phase.

d. Recommended Mitigation. The 10kW SLEEP will be subjected to disposal by the Property Disposal Officer (PDO) according to DOD Manual 4160.21-M, Defense Disposal Manual, and any operating procedures which reflect local, state, and federal laws for property disposal. The Technical Manual for the SLEEP Generator Set will contain any special instructions for disposal.

E. INTRA-SYSTEMS ALTERNATIVE WITHIN EACH PHASE AND THEIR ENVIRONMENT IMPACTS

1. The military design of the 10kW SLEEP will serve to reduce the risk of adverse environmental impact due to changes during its life cycle.

Such procedures require stringent control of the design and any proposed changes. A training program, tailored to meet the needs of operating personnel, will also include awareness of potential environmental impacts. Operator and equipment technical manuals, which include any environmental impact aspects, will be developed to adequately guide personnel working with SLEEP.

F. REFERENCES

1. Draft Acquisition Strategy for 10kW Signature Suppressed Lightweight Electric Energy Plant, 26 September 1986.

2. 40 CFR Part 60, Stationary Internal Combustion Engines: Standards of Performance for New Stationary Sources.

3. Draft Purchase Description for Generator Set, Tactical, Quiet, 10kW.

4. AR 200-1, Environmental Protection and Enhancement, 15 June 1982.

5. AMC Supplement to AR 200-1, dated 1 February 1983.

G. CONCLUSIONS

Based on this assessment of pertinent factors throughout the life cycle of the 10kW SLEEP, the following conclusions are reached:

1. No significant environmental impacts are anticipated during the life cycle of the proposed 10kW SLEEP.

2. An Environmental Impact Statement, as outlined by CEQ and DOD Regulations is not required.

3. A "Finding of No Significant Impact" statement has been prepared and included in Enclosure 1 of this document. The Finding should be distributed to the appropriate interested parties.

FINDING OF NO SIGNIFICANT IMPACT

This Finding of No Significant Impact addresses the development of the 10kW Signature Suppressed Lightweight Electric Energy Plant for use in supplying precise electric power for various military activities worldwide.

An Environmental Assessment (EA) that discusses the design, fabrication, testing, and fielding of the 10kW SLEEP Generator Set has been prepared. A report detailing the EA is available at the Environmental Coordinator's Office, STRBE-Q, US Army Belvoir Research, Development and Engineering Center, Ft. Belvoir, VA 22060-5606. The test sites will be determined at a later date.

The 10kW SLEEP is intended for tactical military deployment when rapid installation of highly mobile, electric generator systems is required. The set shall be a housed unit consisting of a brushless generator, excitation system, governing system, fuel system, 24 dc volt cranking system, control system, protection system, and an engine that can operate on various fuel types. The specifics concerning these systems are described below.

The cranking system consists of a cranking motor, start solenoid, batteries, battery retainer, slave receptacle, battery charging system, and sufficient relays, connectors, switches, and cables to complete the system. The system shall also have a negative ground. After starting, the set shall be capable of operating with the batteries removed. The fuel system shall include all necessary pumps, fuel filters, fuel strainers, water separators, fuel tanks, selector valves, piping, fittings, and mounting provisions. Where applicable, all assemblies shall have their inlet and outlet connections permanently marked and shall be provided with an accessible drain valve located on the bottom of their canisters. The engine speed shall be controlled by a governing system. The governing system shall be "fail-safe". Any failure of the governing system shall stop the engine and disconnect the control power. The generator shall meet all specified

Enclosure 1

requirements. The generator shall use the manufacturer recommended insulation to withstand the temperature rise within the generator. The exciter system shall be electrically isolated from the rest of the set. All electrical power used by the excitation system shall be supplied by the main generator or by a separate generating device as an integral part of the overall generator. The exciter shall have sufficient ceiling voltage to: (a) provide for specified set performance and (b) cause the set output voltage to rise to at least 135 percent of rated value under no load, hot field, rated frequency conditions at 120°F. A drip proof control assembly shall be located at the generator end of the set and shall contain all the instruments, controls, and devices necessary to start, operate, and monitor the set. The set shall be equipped with protective devices to accomplish functions as described herein. Unless otherwise specified, the devices shall be arranged in "fail-safe" circuits. Each device shall be capable of performing its function independently without reference to any other protective device. Each device shall cause the appropriate malfunction indicator to energize.

The set shall operate on diesel fuel conforming to MIL-F-46162 or DF-1, DF-2, or DF-A; diesel fuel conforming to VV-F-800; or JP-8 turbine fuel conforming to MIL-T-83133. The set, while operating on JP-4 turbine fuel conforming to MIL-T-5624 with a cetane rating of 30 to 35, shall meet all specified requirements. However, the rated load may be reduced 15 percent at which time a maximum of 300 hours of operation on JP-4 per 3,000 hours of set operation shall be required.

The 10kW SLEEP is intended as a one-for-one replacement for future procurements of generator sets assigned specific units in the brigade area. The EA does not consider this a major federal action significantly affecting the quality of the human environment. Therefore, it has been determined that an Environmental Impact Statement is not required.

This determination was based upon the consideration of the following factors which are discussed in the EA:

a. The 10kW SLEEP is within the guidelines established by CFR Part 60, Stationary Internal Combustion Engines: Standards of Performance for New Stationary Sources, EPA.

b. A thorough development and prototype testing program has been planned to assure suitable, reliable equipment and provide adequately trained personnel for the operation, maintenance, transport, deployment, storage, and disposal of the generating system.

The responsible official is Mr. John Heavey, Acting Deputy Director, Logistics Support Directorate. US Army Belvoir Research, Development and Engineering Center, Ft. Belvoir, VA 22026-5606.

APPENDIX K

CONFIGURATION MANAGEMENT PLAN

CONFIGURATION MANAGEMENT PLAN

10 KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

13 November 1987

Prepared For:

US ARMY
BELVOIR RESEARCH DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

CONFIGURATION MANAGEMENT PLAN
FOR THE
10 Kilowatt (kW)
SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10kW SLEEP)

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CONFIGURATION MANAGEMENT PLAN
FOR THE
SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANT
(10kW SLEEP)

1. INTRODUCTION

1.1. Description of Configuration Items (CI).

1.1.1. The Signature Suppressed Lightweight Electric Energy Plant (SLEEP) is a member of the DOD Standard Family of Generator Sets. It is managed in accordance with DOD Directive No. 4120.11, dated 19 November 1979, "Standardization of Mobile Electric Power Generating Sources." The technical documentation listed below and in Enclosure 1 currently describes the 10 kilowatt (10kW) SLEEP.

1.1.1.1. Military Specification, MIL-G-52884/5 (Amended), Generator Set, Diesel Engine Driven, 30 kW, 50/60 Hertz, Utility (Tactical), dated 23 January 1986 and Military Specification, IL-G-52889/3, Generator Sets, Diesel Engine Driven, 10 kW, 400 Hertz, Utility (Tactical), dated 1 July 1981.

1.1.1.2. Enclosure 1 lists Specifications, Standards, Documents and Drawings that further describe the 10kW SLEEP.

1.2. Configuration Item Status. SLEEP is in the Proof of Principle Phase of an Army Streamlined Acquisition Process. The specific technical documentation that defines each of these Configuration Items is not yet available.

1.3. Special Features. Managing and standardizing mobile electric power sources used by the Department of Defense is the mission of DOD Project Manager Mobile Electric Power (PM-MEP). The Configuration Items will be

managed by the Project Manager in accordance with the Joint Operating Procedures (JOP), reference 2.5.4.

A draft Purchase Description has been prepared. When approved, it will serve as the Functional Baseline and components will be selected and added to the Baseline.

The 10kW SLEEP set will be fully interchangeable with generator sets of similar power rating. The set will be a Type I (Tactical), Class 2 (Utility) set rated for three modes: Mode II, 400 Hertz (Hz) and Mode III, 60 Hz; and one Direct Current (DC) mode, Mode IV. It will replace existing 10kW generator sets in form, fit, and function in nuclear capable delivery units and associated combat support and combat service support units in the brigade area.

Because the 10kW Sleep will be a DOD managed item, the responsibility for configuration management will be shared by the Army and the Air Force. A Joint Services Configuration Control Board (JSCCB) will be formed with a member of the PM-MEP staff serving as Chairman. Two Configuration Coordinators, one from the Army and one from the Air Force, will be selected to serve on the JSCCB. The Army will be responsible for managing the basic specification and all the common drawings allocated to SLEEP under the original standardization projects.

2. ORGANIZATION

2.1. Responsibilities. The PM-MEP, in conjunction with the mission of managing and standardizing mobile electric power generating sources used by the Department of Defense, is also responsible for providing direction and control for their configuration management. The Project Manager depends on the Services (Air Force, Army, Navy, Marine Corps) for support in conducting configuration management for all mobile electric power sets. Responsibilities for support in configuration management of the items in para. 1.1

will be divided between the Army and Air Force in a manner to be determined. These responsibilities include the following activities as well as the associated funding:

2.1.1. Designate a Configuration Coordinator to coordinate configuration management activities in accordance with Joint Operating Procedures, reference 2.5.4 in this Configuration Management Plan (CMP).

2.1.2. Prepare and maintain the Configuration Identification (technical data packages) necessary to procure the Configuration Items in para. 1.1 (includes coordination with the using Services: Air Force, Army, Navy, and Marine Corps, as required by the JOP).

2.1.3. Maintain all microfilm files, master drawings, lists and specifications used as baseline documents.

2.1.4. Provide reproduction services as necessary to: prepare and process Engineering Change Proposals (ECPs), Requests for Deviations (RFDs), and Requests For Waivers (RFWs), including the microfilm aperture cards of change documents and revised drawings; and fulfill requirements for hard copies and/or microfilm copies of original drawings.

2.1.5. Provide personnel to conduct and participate in configuration audits (see para. 3.5).

2.1.6. Establish and maintain a Configuration Status Accounting and Reporting System in accordance with the policy directives listed in para. 2.5, the Service regulations applicable at the local level, and this CMP.

2.2. Use of Configuration Coordinators. The Army and Air Force shall each designate a Configuration Coordinator for related activities with the JSCCB, contracting officers, contractors, participating Services and the PM-MEP to assure effectiveness of the configuration management program. Responsibilities of the Configuration Coordinators are described in Chapter

6 of the JOP and in refernce 2.5.4 and other sections of this CMP.

2.3. Configuration Control. During the life cycle of the SLEEP generator set and associated optional equipment, configuration control of baselines will be administered by a JSCCB in accordance with this CMP and the policy directives listed in para. 2.5. The JSCCB members shall include representatives nominated by the Air Force, Army, Navy, and Marine Corps to participate in Configuration Management (CM) activities for the 10kW SLEEP set. Under the program, the following general procedures will apply:

2.3.1. Configuration changes to the established baselines and associated equipment will be held to a minimum and the policy shall allow changes absolutely necessary only.

2.3.2. Class I ECPs and major and critical RFWs/RFDs are to be approved or disapproved by the PM-MEP or his authorized representative as Chairman of the JSCCB. The Configuration Coordinators will circulate these ECPs/RFDs/ RFWs to members of the JSCCB for evaluation (unless otherwise requested by PM-MEP). The PM-MEP will consider the recommendations of all the board members, including those of the Configuration Coordinators, when making the approval/disapproval decisions. Prior to forwarding ECPs/RFDs/RFWs to the PM-MEP for approval/disapproval, the Configuration Coordinators shall attempt to resolve all conflicts in the JSCCB recommendations. Original copies of ECP/RFD/RFW are to be forwarded to PM-MEP for Approval/Disapproval Action.

2.3.3. Class II ECPs, minor RFWs, and minor RFDs may be approved/disapproved by the Configuration Coordinators with copies of the documents forwarded to AMCPM-MEP-C and members of the JSCCB.

2.3.4. The contract administrative component shall have primary approval/disapproval authority for minor RFWs in accordance with Chapter 6 of the JOP. Confirmation of the minor classification for each RFW must be obtained from the responsible Configuration Coordinator before any

approval/disapproval actions are taken.

2.3.5. All ECPs/RFDs/RFWs are to be printed in accordance with DOD-STD-480 and must be typewritten or hand-printed in ink.

2.4. Structure. The interfaces and responsibilities of organizations and individuals, including the JSCCB, participating in the CM of mobile electric power generator sets are detailed in Chapter 6 and Appendix F of the JOP, reference 2.5.4 of this CMP.

2.5. Policy Directives. The following documents contain policy and guidance regarding configuration management of DOD mobile electric power generating sources:

2.5.1. DOD Directive 4120.11, 19 November 1979, subject: Standardization of Mobile Electric Power Generating Sources.

2.5.2. DOD Directive 5010.19, 1 May 1979, subject: General Configuration Management.

2.5.3. AR 70-37/NAVMATINST 4130.1A/MCO 4130.1A/AFR 65-3/DSAR 8350.4/NSA/CSS 80-14/DCAC 100-50-2/DNA INST 5010.18, 1 July 1974, Configuration Management.

2.5.4. AR 700-101, AFR 400-50, DLAR 4120.7, NAVMATINST 4120.100A and MCO 11310.8C, subject: Joint Operating Procedures, Management and Standardization of Mobile Electric Power Generating Sources, dated 1 October 1980.

3. BASELINE IDENTIFICATION

3.1. Baselines. Effective CM requires establishing "baselines" for Configuration Items and the controlling all changes to these baselines. Once established, changes to baselines require ECP action in accordance with this CMP. In the case of DOD generator sets, there are two important baselines, the Functional Baseline (used for development), and the Product Baseline (prepared during development and used for production and subsequent reprocurements). These baselines are defined in the Joint Services configuration management regulation, reference 2.5.3 of this CMP.

3.2. Engineering Release Record (ERR). Reference 2.5.3, the joint regulation for configuration management, cites the use of engineering release systems for formally issuing engineering and technical data for use in procurement and manufacturing. The release procedures to be employed by the Services that are assigned configuration management responsibilities should be in accordance with those Services' applicable regulations and local procedures.

3.3. Functional Baseline. Since the 10kW SLEEP is still in the Proof of Principle Phase, no Functional Baseline has been established.

3.4. Product Baseline. The Product Baseline will be established before SLEEP reaches Milestone Decision Review (MDR) III.

3.5. Configuration Management Audits. Configuration management audits are required for development and procurement of the generator sets and optional equipment in para. 1.1. Functional Configuration Audits, Physical Configuration Audits, and Configuration Item Verification Reviews will be conducted: (1) to validate compliance of a developed item with the

Functional Baseline, (2) to validate the technical documentation and establish the Product Baseline, and (3) to validate compliance of production items with their product baselines. Special configuration audits may be desired and conducted (e.g., following the processing of an unusually high volume of ECPs against a particular baseline). The audits shall be conducted in accordance with the requirements of the JOP referenced in 2.5.4 of this plan. The audit procedures will be prepared and released as necessary by PM-MEP.

3.6. Drawings, Data Lists, and Parts Lists. The existing drawings for the items in para. 1.1 were prepared in accordance with DOD-D-1000 and DOD-STD-100. All new and additional required drawings shall be prepared in accordance with these documents and the JOP (Chapter 6) referenced in 2.5.4, and in other sections of this CMP.

3.6.1. Drawing Numbers. The Project Manager (PM) assigns blocks of numbers for the drawings of equipment in para. 1.1. The following blocks of drawing numbers are assigned to the 10kW diesel engine driven generator sets:

Sets and Kits	Drawing Numbers
Top Assembly Drawings, Generator Sets	XX-001 thru XX-499
DOD Drawings (Army control)	XX-500 thru XX-999
Electric Governor, LMU	69-500 thru 69-518
Electric Governor Actuator Assembly	69-600 thru 69-631
Electric Governor Control Unit, 50/60 Hz	69-700 thru 69-738
Electric Governor Control Unit, 400 Hz	69-800 thru 69-815
	and 81-800 thru 81-819

3.6.2. Top Assembly Drawing Numbers for Generator Sets. There have been no top assembly drawing numbers assigned for this 10kW generator.

3.6.3. Top Assembly Drawing Numbers for Optional Equipment. Top assembly

drawing numbers will be assigned to optional equipment as that equipment is identified.

3.6.4. Serialization. Serialization of the configuration items shall be accomplished in accordance with the policy directive listed in para. 2.5.4 of this plan. No serialization of components, other than those normally provided by component manufacturers, is required as there is no plan to trace component changes by serial number.

3.6.5. Identity Marking Procedures. Parts shall be marked in accordance with MIL-STD-130. Detail requirements with guidance are contained therein. The following remarks are included for clarification and additional information:

3.6.5.1. Parts shall be individually marked with the PM Code Identification (30554), a dash, and the DOD part number, except for the following:

(a) Commonly known commercial parts which present no identification problem.

(b) Parts in assemblies which are not normally subject to disassembly or repair.

3.6.5.2. In addition to the PM Code Identification and part number, the manufacturer's code identification prefixed by "MFG" shall also be marked below this number.

3.6.5.3. Identification plates shall be provided for the configuration items listed in para. 1.1 and shall require serialization.

3.6.5.4. Using altered items for DOD Configuration Items should be limited to those which are necessary or offer significant benefit to the Government (i.e., help eliminate or avoid creating a supply item). To help accomplish this, the original vendor should be notified of the required alterations so he/she may elect to incorporate the alterations and assign the item a new

vendor part number. Vendor items which do require alteration by a contractor shall be identified with the PM Code Identification (30554), a dash, and DOD part number. The code identification number of the manufacturer or contractor making the alteration shall be marked below the DOD identification and part number. The original vendor identification number shall be obliterated without damage to the item.

3.6.5.5. When no alterations are made to specification control or source control items, prime contractors shall not remove the original vendor's identification and part number, nor add their own identification number to the item or identification plate. Parts identified on specification control drawings are not to be marked with the DOD part number. Parts identified on source control drawings shall be marked with the PM Code Identification (30554), the notation "SOCN," and the DOD part number. (The vendor's identification and part number need not be removed.)

4. CONFIGURATION CHANGES/DEVIATIONS/WAIVERS

4.1. Baseline Changes/Deviations/Waivers Procedures. All the procedures governing the processing of changes, deviations, and waivers relating to the baselines established for the configuration items listed in para. 1.1 are contained in Chapter 6 and Appendix F of the JOP (reference 2.5.4) and para. 1 of this CMP.

4.2. Membership of the Joint Services Configuration Control Board. As indicated in paragraphs 1.3 and 2.3, a JSCCB controls all changes, deviations, and waivers to the Functional and Product Baselines. Establishment of the JSCCB is in accordance with Chapter 6 of the JOP (reference 2.5.4). A list prepared and distributed by the Project Manager's Office identifies the JSCCB members with addresses and telephone numbers. The periodic update of this list of JSCCB members is the responsibility of the Project Manager's Office.

5. STATUS ACCOUNTING

5.1. Status Accounting. Status accounting procedures shall be used throughout the life cycle of each identified Configuration Item assuring:

5.1.1. The integrity of the configuration baselines is maintained.

5.1.2. There is traceability of ECPs/RFWs/RFDs.

5.1.3. All changes involving documentation (drawings, specifications, technical manuals, provisioning, etc.), cataloging, contract modifications, and retrofits resulting from approved ECPs/RFWs/RFDs are completed.

5.1.4. Pertinent information (identified in para. 5.3, Data Bank Contents) is available on an as-required basis to assist the Services in the management and support of their 10kW generator sets and related equipment.

The Services (Army and Air Force) that have been assigned Configuration Management responsibilities for the Configuration Items in this plan shall develop and maintain status accounting and reporting procedures in accordance with the requirements specified in their Configuration Management regulations, the Policy Directives in para. 2.5, and this CMP.

5.2. Data Bank Location. The data banks for the Configuration Items covered by this plan are located at Belvoir Research and Development Center, Fort Belvoir, Virginia, for the Army assigned items and at Sacramento ALC, California, for the Air Force assigned items.

5.3. Data Bank Content. The Army and Air Force data banks shall contain the Configuration Identification and Configuration Management records consistent with the configuration management practices and formats

prescribed by the Army and Air Force regulations and the directives in para. 2.5. The records are capable of revealing, as a minimum and on a continuing basis, the current status of the following configuration management data, information, and actions:

5.3.1. Configuration Identification: Baselines, purchase descriptions, specifications, drawings, implementation of approved ECPs/RFDs/RFWs, audits.

5.3.2. Configuration Item Data: Nomenclature, model numbers, National Stock Numbers (NSNs), manufacturer's codes/part numbers.

5.3.3. Configuration Control: JSCCB determinations, identification of approved/disapproved ECPs/RFWs/RFDs, implementation cost/savings.

5.3.4. Production Data: Configuration Identifications, quantities produced and identified by contract numbers, production effectivity of ECPs/RFWs/RFDs by generator set or item serial numbers, contract modifications for ECPs/RFWs/RFDs.

5.3.5. Retrofit: Identification of alterations/modifications/retrofits. (Note: Each Service will be responsible for maintaining their own records that identify the specific units in their inventory.)

5.3.6. Actions Related to Approved ECPs/RFWs/RFDs: Update specifications, drawings, technical manuals, provisioning documentation and cataloging.

5.4. Status Reporting.

5.4.1. Status reports shall be prepared once every quarter by the Services assigned CM responsibility in para. 2.1 to:

5.4.1.1. Identify the ECPs/RFWs/RFDs (including Class IIs and minors) approved for baseline, contract and retrofit applicability.

5.4.1.2. Indicate initiation or completion dates for those actions accomplished as the result of the implementation of approved ECPs/ RFWs/RFDs (i.e., documentation revisions, retrofits, contract modifications).

5.4.2. Each report shall be in the format shown in Table 1 of this report. The Army Configuration Coordinator shall prepare a status report for the 10kW SLEEP set and the Army assigned optional equipment; the Air Force Configuration Coordinator shall prepare a report for the 10kW SLEEP set and the Air Force assigned optional equipment. The report shall be forwarded by the Configuration Coordinators to the PM-MEP and the JSCCB members on the first working day of each quarter.

5.4.3. For approved ECPs/RFWs/RFDs, the JSCCB members identified in the JOP as having areas of responsibilities relating to technical data changes, retrofit instructions, contract modifications, technical manuals, provisioning documentation and cataloging shall be responsible for informing the appropriate Configuration Coordinator that the status report actions have been implemented. The information must be provided by the representatives on a timely basis. The information should also be forwarded to the Configuration Coordinator to arrive not later than fifteen days prior to the reporting dates (para. 5.4.2). When the required data is not received from the representatives, the Configuration Coordinator shall leave the related chart spaces blank to signify that the identified actions have not yet been accomplished. For spaces that are not applicable, insert "N/A".

5.4.4. A numerical listing of the ECPs/RFWs/RFDs is not required. However, to assist tracking and accountability, each report shall be paginated. Once submitted to PM-MEP and the JSCCB, a completed actions list need not be resubmitted. The sheet size to be used is optional.

5.4.5. The preparation and submission of the status reports required herein should not preclude preparation of any other reports prepared in compliance with Army and Air Force configuration management regulations.

5.5 Configuration Item File. Each Service assigned CM responsibilities in para. 2.1 is responsible for maintaining the configuration end item files for their assigned configuration items (CI). The elements contained in the file should include the pertinent correspondence and all other information and data to document the complete history of the CIs.

Table 1. *Sample Status Report*

DOD MOBILE ELECTRIC POWER CONFIGURATION STATUS REPORT
STATUS OF APPROVED ECPs/FRWs/RFDs

10kW SLEEP Generator Sets and Associated Optional Equipment

Sheet No. ______

ECP/RFW/RFD					MFP No.	Contract No.	Contract Mod No.	Revision/Retrofit Action Dates					
No.	Class	Descr.	Date										
			Prepared	Approved				Spec.	Dwg.	TM	Provision	Catalog	Retrofit
1	2	3	4	5	6	7	8	9	10	11	12	13	14

NOTES:

(a) Column 2: For ECPs use I or II; for RFWs/RFDs use C-Critical, MJ-Major, MN-Minor.

(b) Column 5: Enter disapproved/withdrawn/etc. as appropriate for ECP/RFD/RFWs that are not approved.

(c) Columns 7 thru 14: Insert "N/A" when not applicable.

(d) Columns 9 thru 13: Date final instructions forwarded to the Government elements responsible for making revisions to Tech Data/TMs/Provisioning/Cataloging.

(e) Column 14: Date final release of retrofit instructions made to Services.

ENCLOSURE 1

DESCRIPTION OF 10KW SLEEP

Item	Date	Description
Federal Specification:		
O-A-548D	12-Jan-1970	Antifreeze/Coolant, Engine, Ethylene Glycol, Inhibited, Concentrated.
O-I-490A	19-Jun-1973	Inhibitor, Corrosion, Liquid Cooling System.
W-R-550A	18-Aug-1977	Rod, Ground (With Attachments).
QQ-P-416E	27-Feb-1987	Plating, Cadmium (Electrodeposited).
VV-F-800C	26-Jul-1985	Fuel Oil, Diesel.
ZZ-B-190A	13-Nov-1981	Belts, V, Engine Accessory Drive.
FED-STD-H28	28-Aug-1985	Screw Thread Standards for Federal Services.
Forest Service Standard 5100-1a		Spark Arresting Exhaust Systems.
Military Specification:		
MIL-T-704J	28-May-1985	Treatment and Painting of Material.
MIL-E-917D	16-Dec-1966	Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-L-2104D	01-Apr-1983	Lubricating Oil, Internal Combustion Engine, Tactical Service.
MIL-L-2105C	08-Apr-1981	Lubricating Oil, Gear, Multi Purpose.
MIL-S-3950F	14-Feb-1976	Switch, Toggle, Environmentally Sealed, General, Specification For.
MIL-W-5088K	28-Dec-1984	Wiring, Aerospace Vehicle.
MIL-H-5606E	02-Mar-1984	Hydraulic Fluid, Petroleum Base, Aircraft Missile, and Ordnance.
MIL-T-5624L	10-Aug-1983	Turbine Fuels, Aviation, Grades JP-4 and JP-5.
MIL-H-6083E	14-Aug-1986	Hydraulic Fluid, Petroleum Base.

Item	Date	Description
MIL-A-8421F	25-Oct-1974	Air Transportability Requirements, General Specifications For.
MIL-W-8777C	11-Apr-1968	Wire, Electrical, Silicone Insulated, Copper,
MIL-E-10062E	14-Aug-1986	Engine, Preparation for Shipment and Storage of.
MIL-G-10924D	13-Jun-1983	Grease, Automotive and Artillery.
MIL-A-11755D	21-Aug-1981	Antifreeze, Arctic-type.
MIL-C-16173D	19-Nov-1968	Corrosion Preventive Compound, Solvent Cutback, Cold-Application.
MIL-S-19500G	03-Mar-1986	Semiconductor Device, General Specification For.
MIL-L-21260C	11-Feb-1981	Lubricating Oil, Internal Combustion Engine, Preservative and Break-in.
MIL-G-28554B	14-Sep-1983	Generator Set, Mobile Electric Power and Supplemental Equipment Packaging of.
MIL-M-38510F	07-Nov-1986	Microcircuits, General Specification for.
MIL-I-46058C	08-Nov-1982	Insulating Compound, Electrical (For Coating Printed Circuit Assemblies).
MIL-A-46153B	17-Mar-1981	Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package.
MIL-F-46162C	12-Nov-1985	Fuel, Diesel, Reference Grade.
MIL-L-46167A	07-Jan-1985	Lubricating Oil, Internal Combustion Engine, Arctic.
MIL-A-52363B	17-Jan-1983	Air Cleaners, Intake: Dry-Type (For Internal Combustion Engine).
MIL-W-81044B	31-Dec-1973	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulation, Copper or Copper Alloy.
MIL-T-83133A	04-Apr-1980	Turbine Fuel, Aviation, Kerosene, Grade JP-8.
MIL-STD-105D	29-Apr-1963	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-130F	21-May-1982	Identification Marking of US Military Property.

Item	Date	Description
MIL-STD-195	07-Feb-1958	Marking of Connections for Electrical Assemblies.
MIL-STD-199C	28-Aug-1981	Resistor, Selection and Use of.
MIL-STD-275E	31-Dec-1984	Printed Wiring for Electronic Equipment.
MIL-STD-454K	14-Feb-1986	Standard General Requirements for Electronic Equipment.
MIL-STD-461C	04-Aug-1986	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	31-July-1967	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-633E	22-Feb-1980	Mobile Electric Power, Engine Generator, Standard Family, General Characteristics.
MIL-STD-705B	26-Jun-1972	Generator Sets, Engine-Driven, Methods of Tests and Instructions.
MIL-STD-810D	19-Jul-1983	Environmental Test & Engineering Guidelines.
MIL-STD-882B	30-Mar-1984	System Safety Program Requirements.
MIL-STD-889B	07-Nov-1979	Dissimilar Metals.
MIL-STD-1400B	19-Dec-1975	Engine, Gasoline or Diesel, Methods of Test.
MIL-STD-1472C	02-May-1981	Human Engineering Design Criteria for Military Systems, Equipment and Facilities.
MIL-STD-1474B	10-Oct-1980	Noise Limits for Army Material.
MS-25331C	01-Feb-1985	Light Assembly, Press to Test Indicator.
MS-5471C	06-Jan-1969	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200 Deg. C, Polyester Jacket.
MS-35000P	11-Jan-1984	Battery, Storage, Lead-Acid, Waterproof.
MS-51321D	28-Jan-1986	Pump, Fuel, Electrical, 24 Volts DC70 25 GPH Capacity.
MS-52131	17-Dec-1975	Connectors, Plug, Electrical Intervehicle Power Cable.
MS-52149A	11-Jan-1983	Battery, Storage, Lead Acid, (Low Maintenance).

Item	Date	Description
MS-90725D	02-Jul-1974	Screw, Cap, Hexagon Head (Finished Hexagon Bolt), Steel, Grade 5, Cadmium Plated, UNC-2A.

Military Documents:

MIL-HDBK-705B	26-Jun-1972	Generator Sets, Electrical, Measurements and Instrumentation.
TOP 1-2-610		Human Factors Engineering: Test Procedures.
TOP 1-2-610		Human Factors Engineering: Part II, Guide for Evaluation.
DA Pamphlet No. 700-21-1		The Army Test, Measurement and Diagnostic Equipment (TMDE) Preferred Items List.
DA Pamphlet No. 700-21-1		Nuclear Survivability Criteria for Commercial Generator Sets and Assemblages.
DA Pamphlet No. 700-21-1		NBC Contamination Survivability Criteria for Army Materiel (Revised).

Drawings:

US Army Belvoir Research, Development and Engineering Center

69-539	69-692	69-776
69-561	69-693	69-777
69-651	69-693	70-513
69-662	69-694	72-2459
69-663	69-695	73-0506
	69-774	

Project Manager-Mobile Electric Power

All Code 30544 Drawings

APPENDIX L

BASELINE COST ESTIMATE

BASELINE COST ESTIMATE

10KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

24 FEBRUARY 1987

Prepared For:

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

BASELINE COST ESTIMATE

for

10 KILOWATT
SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS
(10KW SLEEP)

(FY88 CONSTANT DOLLARS, $000's)

I. Purpose

The combat developer has requested that the US Army Research, Development and Engineering Center (BELVOIR) provide estimated cost information for the development of the 10 kiloWatt Signature Suppressed Lightweight Electric Energy Plant (10kW SLEEP). This Baseline Cost Estimate (BCE) is a draft estimate and should not be used as official Department of the Army cost data. The Life Cycle Cost Model (LCCM) was used to develop the five major BCE equations.

II. System Description

The 10kW SLEEP shall be a lightweight, mobile, housed unit consisting of a brushless generator, excitation system, governing system, fuel system, 24 Volt DC cranking system, control system, suppression system to prevent aural and thermal detection, and an engine that can operate on the fuels specified in the Purchase Description (PD) (Section 3.11).

SLEEP will be employed by units where high reliability, mobility, and signature suppression are essential to mission performance and survivability. SLEEP will reduce the potential of endangering personnel and equipment in the set vicinity, and will improve the using unit's ability to complete assigned missions.

SLEEP will be used to provide electrical power for Command, Control, Communication, and Intelligence (C^3I) systems; generate fire control data; conduct tactical operations; and provide maintenance and support activities of systems in a mobile field environment. SLEEP, which will be used during all phases of peacetime training and under all wartime conditions, will be fully interchangeable in form, fit, and function with existing generator sets of similar power ratings and will be capable of being transported by the same assets as current generators.

III. Risks

The technical feasibility of the proposed silent generator sets is the major risk consideration. The production of the sets will utilize a mixture of new technology and standard commercial and military parts and components in the supply system. A medium risk level is associated with achieving the low aural and thermal signatures within the weight constraints.

IV. Cost Drivers

The anticipated principal cost drivers are associated with the components and new technology integration. Specific cost drivers will be the "design target" indicated in the PD such as: size (30 cubic feet), weight (650 pounds), aural non-detectability (100 meters), thermal non-detectability (4000 meters), NBC survivability, and the reliability criteria. Other cost drivers are associated with new equipment training (NET). The overall cost and growth of the program will be constrained by the competitively awarded production contract with annual economic price adjustments to compensate for inflation.

V. Cost Range and Sensitivity Analysis

Based on the inherent cost estimating uncertainty of the funding implications, the procurment cost range for the SLEEP system was given to be between \$400M and \$500M, as determined from the Operational and Organizational (O&O) Plan dated 1 May 1985. The sensitivity to variations

in the cost data will depend on the level of constraints, the level of demand characteristics specified, and the possible technological improvements on each variable in the process being modelled. These variations have yet to be determined.

VI. Assumptions

A. As a result of the significant unknowns that currently exist in the program, assumptions were made in the preparating the BCE. For example, SLEEP developmental cost figures were based on the costs previously derived to develop the 10kW Enhanced Commercial Generator Sets and Assemblages (CGSA). This is a valid assumption because of the similarities of technical and operational performance requirements of the two programs. Other assumptions, sources, and derivations of each cost element are provided in the SLEEP BCE JUSTIFICATION as Attachment I.

B. All cost element results are in FY88 dollars.

C. All direct and indirect costs are included in the individual dual cost element calculations.

D. The BCE contains estimated costs for 1660 units. The quantity is based on the number of 10kW generator sets specified in the Required Operational Capability (ROC) dated 10 Jan 84.

E. Only one SLEEP size and type will be developed.

F. Three modes of SLEEP will be developed.

G. The appropriation type and time-phases for the R&D effort were assumed as follows:

1. Advanced Development, 6.3, from FY88 thru FY90, approximately a 1-1/2 year effort.

2. Engineering Development, 6.4, from FY90 thru FY92, approximately a 2-year effcrt.

H. The Production phase is assumed to be 5 years, the sustainment phase is assumed to be 12 years, and the Fielding phase will start in the first production year and assumed to have a duration of 6 years.

VII. Conclusions

A. The Research and Development (R&D) cost is estimated at $13,774K for the Advanced and Engineering Development efforts. This estimate is based on the assumption that the subsystem will utilize new technologies requiring significant development.

B. The Procurement cost, including Military Construction which is $0, is estimated to be approximately $30.4M.

C. The sustainment cost, including fielding, is estimated to be approximately $16.3M. Sustainment costs are totalled over 12 operating years.

D. The total life cycle cost of SLEEP is estimated at $60.5M.

ATTACHMENT I

SIGNATURE SUPPRESSED LIGHTWEIGHT ELECTRIC ENERGY PLANTS

(SLEEP)

BCE JUSTIFICATION
(FY88 Constant Dollars, $000's)

1.0 DEVELOPMENT

1.01 RESEARCH AND DEVELOPMENT

1.011 DEVELOPMENT ENGINEERING

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	127	127	127	381
Non-Gov't	690	690	345	1725
Total	817	817	472	2106

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	254	127	127	508
Non-Gov't	1007	760	133	1900
Total	1261	887	260	2408

C. SOURCE & DERIVATION

1. Government

The Project Engineer estimates 1.0 man-years (MY) per year to manage, coordinate and document the development effort, based on previous development programs. The BELVOIR man-year rate is estimated at $123K including technical services. The Government personnel cost, therefore, is estimated as:

1.0 MY x $123K/MY = $123K

The Project Engineer estimates the Advanced Development (AD) effort will require 18 man-trips TDY and the Engineering Development (ED) effort will require 24 man-trips TDY. The cost per man-trip, based on previous TDY experience, is

estimated at $.7K. Dividing the man-trips equally for each year yields:

6 man-trips x $.7K/man-trip = $4K

The estimated Government effort for development engineering per year is:

$123K (personnel) + $4K (TDY) = $127K

2. Non-Government

The Project Engineer estimates a total contractor effort of 11 MY for (AD) and 11 MY for (ED). This estimate is derived from comparison with other development efforts and analysis of sub-element task efforts as follows:

	ED	AD
Basic Subsystem Design	4 MY	3 MY
Specific Design Factors	5 MY	3 MY
Integration	3 MY	2 MY
Trade-off Analysis/Evaluation	1 MY	3 MY
Design Finalization	2 MY	1 MY
Coordination	2 MY	1 MY

The basic design effort includes initial design of the engine, generator, hardware, and accessories. The specific design factors effort includes design incorporation of specific features such as weight reduction and signature suppression. The integration effort includes packaging and controls design. The remaining sub-element task efforts are as listed above.

The cost per Non-Government MY is estimated at $125K based on recent contract rates. The Non-Government personnel cost, therefore, for both AD and ED, is estimated as:

13 MY x $125K/MY = $1,625K
14 MY x $125K/MY = $1,750K

The Project Engineer estimates contractor material and test equipment costs of $100K for the AD effort and $150K for the ED effort, based on previous development programs.

The estimated Non-Government AD and ED effort for development engineering is:

$1,625K (personnel) + $100K (material) = $1,725K
$1,750K (personnel) + $150K (material) = $1,900K

The Non-Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

1.012 PRODUCIBILITY ENGINEERING AND PLANNING (PEP)

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	30.75	30.75	61.5	123
Non-Gov't	66	165	99	453
Total	96.75	195.75	160.5	576

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	49.2	49.2	24.6	123
Non-Gov't	214	214	107	535
Total	263.2	263.2	131.6	658

C. SOURCE AND DERIVATION

1. Government

The Project Engineer estimates a 1 MY effort for review of the AD technical data package and a 1 MY effort for review of the ED technical data package.

The estimated Government effort for PEP for both AD and ED is:

$123K/MY x 1 MY = $123K

The Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

2. Non-Government

The average number of drawings for military standard generator sets in this size range is 201. The Project Engineer estimates that the technical data package for SLEEP will include, at least, the sum of the current generator set plus some integration, packaging and controls drawings for a total of approximately 400 drawings.

Based on past experience the Engineering Division of the Engineer Service Support Laboratory report drawings cost between $100 to $500 each depending on the level of complexity.

The Project Engineer estimates that the AD drawings will be prepared to the least complex requirements at $200 per drawing and that quality control, testing, and manufacturing requirements generation will require a 2 MY effort. The estimated AD cost for PEP is:

(400 drawings x $200/drawing) + (2 MY x $125K/MY)
= $330K

The Project Engineer estimates that the ED drawings will be prepared at a cost of $400 per drawing and the quality control, testing, and manufacturing requirements generation will require a 3 MY effort. The estimated ED cost for PEP is:

(400 drawings x $400/drawing) + (3 MY x $125K/MY)
= $535K

The Non-Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

D. ASSUMPTIONS

The concept selection and results of other programs should not significantly impact the Government PEP effort or the Non-Government effort for the generation of quality control, testing, and manufacturing requirements.

1.013 TOOLING

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	--	--	--	0
Non-Gov't	58.4	58.4	29.2	146
Total	58.4	58.4	29.2	146

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	--	--	--	0
Non-Gov't	77.38	58.4	10.2	146
Total	77.38	58.4	10.2	146

C. SOURCE & DERIVATION

1. Government - None

2. Non-Government

The Project Engineer Estimates that the total tooling effort will be approximately 10% of the Developmental Engineering effort based on previous development programs which yields $146K for AD and $146K for ED.

D. ASSUMPTIONS

The tooling effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

1.014 PROTOTYPE MANUFACTURING

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	--	--	--	0
Non-Gov't	240	720	240	1200
Total	240	720	240	1200

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	--	--	--	0
Non-Gov't	1200	1008	192	2400
Total	1200	1008	192	2400

C. SOURCE & DERIVATION

1. Government - None

2. Non-Government

The Project Engineer estimates the cost to manufacture units at $100K per unit. The cost of prototypes include material, fabrication labor, quality control/inspection, and rework/spare parts as follows:

Material	$20K
Fabrication	$40K
QC/Inspection	$20K
Rework/Spares	$20K

The Project Engineer estimates that a maximum of 12 AD prototypes and 24 ED prototypes will be required. Therefore, the prototype manufacturing effort is estimated as $700K for AD and $1,100K for ED.

D. ASSUMPTIONS

The prototype manufacturing effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

1.02 DATA

A. ADVANCED DEVELOPMENT(6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	32.5	65	32.5	130
Non-Gov't	25	50	25	100
Total	57.5	115	57.5	230

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	52	52	26	130
Non-Gov't	120	120	60	300
Total	172	172	86	430

C. SOURCE & DERIVATION

1. Government

The Project Engineer estimates 1 MY for AD and 1 MY for ED to manage and coordinate the ILS effort, based on previous experience. Using a man-year rate of $123K, the Government personnel cost is estimated for both AD and ED as:

1 MY x $123K/MY = $123K

The Project Engineer estimates 10 man-trips TDY will be required for AD and 10 man-trips will be required for ED to support the ILS effort. Using a man-trip rate of $.7K the estimated TDY cost for both AD and ED as:

10 man-trips x $.7K/man-trip = $7K

The estimated Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

2. Non-Government

The Project Engineer estimates the AD Data effort at $100K and the ED Data effort at $300K based on previous experience.

The Data effort includes Draft Equipment Publications (DEP's), Logistic Support Analysis and Record (LSA/LSAR), Physical Teardown (PTEAR), and other supporting plans, records, and reports.

The estimated Non-Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

D. ASSUMPTIONS

The concept selection should not have a significant impact on the cost of the ILS effort.

1.03 SYSTEM TEST AND EVALUATION

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	72.5	72.5	580	725
Non-Gov't	--	31	124	155
Total	72.5	103.5	704	880

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	100	100	800	1000
Non-Gov't	--	35	140	175
Total	100	135	940	1175

C. SOURCE & DERIVATION

1. Government

The Project Engineer estimates the Government test and evaluation effort at $725K for AD and $1000K for ED. This estimate is derived from comparison with other test efforts and analysis of the sub-element tasks as follows:

	AD	ED
Test Planning	75	75
Materials	50	75
DT Conduct	400	600
OT Conduct	200	250
TOTAL	775	1000

The test planning task includes the cost of .5 MY for personnel and 20 man-trips TDY for TIWG participation. The materials task includes purchase of test instrumentation, equipment, and consumables. The DT conduct task includes personnel and site usage costs. The OT conduct task is estimated as a ratio of DT cost based on the anticipated unit usage split.

The estimated Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

2. Non-Government

The Project Engineer estimates that $30K for material and 1 MY will be required for contractor quality conformance and performance qualification testing for AD. Therefore, the Non-Government AD testing cost is estimated as:

$30K + (1 MY x $125K/MY) = $155K

The Project Engineer estimated that $50K for material and 1 MY will be required for contractor testing for ED. Therefore, the Non-Government ED testing cost is estimated as:

$50K + (1 MY x $125K/MY) = $175K

The estimated Non-Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

1.04 SYSTEM/PROJECT MANAGEMENT

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	62	62	62	186
Non-Gov't	--	--	--	0
Total	62	62	62	186

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	124	62	62	248
Non-Gov't	--	--	--	0
Total	124	62	62	248

C. SOURCE & DERIVATION

1. Government

The involvement of Project Manager, Mobile Electric Power (PM-MEP) is estimated at 1 MY per year during AD and ED. The MY rate for PM-MEP is $58K. The Project Engineer estimates 5 mantrips TDY per year will be required for the project management effort at a man-trip rate of $.7K. Therefore, the Government project management cost per year is estimated as:

(1 MY x $58K/MY) + (5 man-trips x $.7K/man-trip) = $62K

2. Non-Government - None

D. ASSUMPTIONS

The concept selection should not have a significant impact on the cost of the test and evaluation effort.

1.05 TRAINING

A. ADVANCED DEVELOPMENT (6.3)

	FY88	FY89	FY90	TOTAL
GOV'T	26	52	26	104
Non-Gov't	87.5	175	87.5	350
Total	113.5	227	113.5	454

B. ENGINEERING DEVELOPMENT (6.4)

	FY91	FY92	FY93	TOTAL
GOV'T	26	52	26	104
Non-Gov't	220	275	55	550
Total	246	327	81	654

C. SOURCE & DERIVATION

The Project Engineer estimates 1 MY for AD and 1 MY for ED to manage and coordinate this training effort, based on previous experience. Using a man-year rate of $97K, the Government personnel cost is estimated for both AD and ED as:

1 MY x $97K/MY = $97K

The Project Engineer estimates 10 man-trips TDY will be required for AD and 10 man-trips will be required for ED. Using a man-trip rate of $.7K the estimated TDY cost for both AD and ED as:

10 man-trips x $.7K/man-trip = $7K

The estimated Government effort has been divided between the fiscal years based on the anticipated time-phasing of the development program.

2. Non-Government

The Project Engineer estimates the AD Data effort at $350K and the ED Data effort at $550K based on previous experience.

The estimated Non-Government effort has been divided between the fiscal years based on the anticipated timephasing of the development program.

D. RANGE ANALYSIS

The concept selection should not have a significant impact on the cost of the training effort.

1.06 <u>FACILITIES</u> - None

1.07 <u>OTHER RDTE FUNDED DEVELOPMENT</u> - None

2.0 <u>PRODUCTION</u>

2.01 <u>NON-RECURRING PRODUCTION</u>

2.011 <u>INITIAL PRODUCTION FACILITIES</u>

A. ESTIMATE

	TOTAL
Hard tooling	$25000
Production Line Set-up	$25000
Total	$50000

B. SOURCE & DERIVATION

The Project Engineer estimates initial tooling materials cost and production line set-up cost at $50K based on comparison with other programs.

It is assumed that SLEEP will be comparable in complexity and will require approximately the five times the level of special tooling and fixtures as the Enhanced CGSA program.

2.012 PRODUCTION BASE SUPPORT

No production base support required for this project.

2.013 DEPOT MAINTENANCE PRODUCTION EQUIPMENT

No depot maintenance production is required.

2.014 OTHER NON-RECURRING PRODUCTION

A. SOURCE & DERIVATION

The Project Engineer estimates 4.5 MY for initial production design and set-up and analysis of sub-element tasks as follows:

Tooling Design	1 MY
Manufacturing Planning	1 MY
Installation and Set-up	2 MY
Tooling Record Maintenance	.5 MY

Using a contractor man-year rate of 125K yields:

4.5 MY x $125K/MY = $562.5K.

2.02 RECURRING PRODUCTION

2.021 MANUFACTURING

A. ESTIMATE

First Unit Cost = $ 20,244

B. SOURCE & DERIVATION

The first unit cost are based on the estimates for the commercial generator sets. Those costs were inflated to constant 1988 dollars. It was estimated by PE that a 25% increase in unit cost would result for the 10kW sizes. The first unit cost was estimated to increase because of the more stringent requirements. The first unit cost includes material costs, overhead, G & A, profit, sustaining tooling costs, and any regular quality control tests that the manufacturer may perform. Trailer costs have not been included in this estimate. No new trailers will necessarily be procured for these additional generator sets. A 95% learning rate was assumed since this a new program. Derivation taken from the Enhanced CGSA program.

C. ASSUMPTIONS

The first unit cost for SLEEP are comparative to the cost of current and military equipment. The estimate stemmed from

increasing by 10% the estimate derived from the Enhanced Commercial Generator program since that program is the most comparative.

2.022 RECURRING ENGINEERING

A. ESTIMATE

	TOTAL
GOV'T	123K
Non-Gov't	250K
Total	373K

B. SOURCE & DERIVATION

The Project Engineer estimates a recurring engineering effort for Government production support of 1 MY for the first year of production. Using the BELVOIR MY rate of $123K yields:

1 MY x $123K/MY = $123K

The Project Engineer estimates the contractor recurring engineering effort will be 2 MYs. Using a MY rate of $125K yields:

2 MY x $125K/MY = $250K

Estimate taken from the Enhanced CGSA program. Ms. Janet Garrison, Belvoir, (4270) provided the cost per government manyear. The number of manyears required and cost both estimated by the PE.

2.023 SUSTAINING TOOLING

Cost is included in the manufacturing costs.

2.024 QUALITY CONTROL

A. ESTIMATE

QC = $ 39,324
FAT = $ 750,000
HEMP testing = $ 100,000

B. SOURCE & DERIVATION

The Project Engineer estimates the quality control effort excluding the cost of First Article Testing as 10% of the recurring engineering costs and sustaining tooling (cost element 2.021 and 2.023) which yields:

($373K + $)0 x 0.1 = $37,300

The Project Engineer estimates that the First Article Test cost will be comparable to previous First Article test effort. The 10kW

SLEEP sets First Article Test effort cost was estimated $750K plus $100K for HEMP testing.

$750K + 100K = $850K

The total Quality Control cost is estimated as:

$850K + $37K = $887K

Estimate includes all recurring FAT costs provided by Ms. Janet Garrison taken from Enhanced CGSA program.

2.03 ENGINEERING CHANGES

A. ESTIMATE

% of MFG = .20

B. SOURCE & DERIVATION

The percentage of manufacturing assumed for engineering changes is the PE's best estimate. This is Based on percentages ranging from 3-10 % of manufacturing costs over the first two production years of standard generator projects. This estimate was taken from Enhanced CGSA program.

2.04 SYSTEM TEST AND EVALUATION

A. SOURCE & DERIVATION

Ms. Janet Garrison (4270) provided the estimate as the data costs for a first time buy. It includes manual costs, provisioning for data, and level III drawings. This estimate was also taken from Enhanced CGSA program.

B. ASSUMPTIONS

The data requirements for this project will be those of an initial buy.

2.05 SYSTEM/PROJECT MANAGEMENT

A. ESTIMATE

Non-recurring FAT = $ 500K

B. SOURCE & DERIVATION

This estimate is for non-recurring FAT costs. The testing is more extensive since this is the initial procurement of a new item. System test and evaluation costs include only non-recurring test costs. This estimate was provided by the PE.

2.06 TRAINING, SERVICE AND EQUIPMENT

A. SOURCE & DERIVATION

Ms. Janet Garrison (4270) provided this $30K estimate based on the comparable 10kW Enhanced CGSA program plus a 10% increase.

2.07 INITIAL SPARES

A. ESTIMATE

% of MFG for Initial Spares = 20%

B. SOURCE & DERIVATION

The percentage of manufacturing cost to be allotted for initial spare and repair parts was estimated by the Project Engineer. The percentage was estimated to equal 20 the amount of the Enhanced CGSA program.

2.08 OPERATIONAL/SITE ACTIVITY

No operational site activity is required for this program.

2.09 OTHER PROCUREMENT FUNDED PRODUCTION

A. SOURCE & DERIVATION

The PE estimated that 180K per year would be required to complete development work and testing associated with the production phase. This estimate is based on 1 and 1/2 times that of standard generator projects and the Enhanced CGSA program.

3.0 MILITARY CONSTRUCTION - None Identified.

4.0 FIELDING

4.01 SYSTEM TEST & EVALUATION

No O & M funded testing is planned for this program.

4.02 TRAINING, SERVICE & EQUIPMENT

A. ESTIMATE

Class prep $ = 46,000
TDY = $ 112,000
Total MY $ = 24,000

B. SOURCE & DERIVATION

This estimate is double the estimate provided Ms. Janet Garrison (4270), for the Enhanced CGSA program. It includes dollars for class prep, TDY, and total MYs. The number of classes is 21 and the number of maintenance classes is 9.

4.03 TRANSPORTATION

A. ESTIMATE

THEATER	UNITS	$/UNIT/S.T.
CONUS	446	133
EUROPE	628	685
KOREA	63	591
PACIFIC	512	576
ALASKA	8	471
PANAMA	3	483

2ND DEST COST = (446 (Wt/2000) x 133) x (628 (Wt/2000) x 685) x (63 (Wt/2000) x 591) x (512 (Wt/2000) x 576) x (8 (Wt/2000) x 471) x (3 (Wt/2000) x 483) = 268,808

B. SOURCE & DERIVATION

The system dry weight was multiplied by a 10% packaging factor and then converted to short tons. (1 S.T. = 2000 lbs) This value was then multiplied by the shipping factor cost for both the first and second destinations. All sets assumed to have first destination CONUS. The dry set weight is estimated at 650 pounds. The weights do not include trailer weights. The shipping rates were provided by Ms. Janet Garrison. The quantities to each theater were calculated and based on the Enhanced CGSA program.

4.04 INITIAL REPAIR PARTS

A. SOURCE & DERIVATION

The cost of initial repair parts is PROC funded and is included in the estimate given in cell 2.07.

4.05 SYSTEM SPECIFIC BASE OPERATIONAL SUPPORT

No system specific base operational support is required for this project.

4.06 OTHER O&M FUNDED FIELDING

A. ESTIMATE

(200 MHRS x $ 33.85) = $ 6,770

B. SOURCE & DERIVATION

It was estimated that 200 manhours, at $33.85 per manhour, would be required to prepare a depot for the overhaul of a new item. This estimate is five times that for the Enhanced CGSA program. It also includes $300 per set for packaging.

5.0 SUSTAINMENT

5.01 REPLENISHMENT REPAIR PARTS

5.011 REPLACE REPAIR PARTS

A. ESTIMATE

% of MFG = (1.95 x .60) = 1.17

B. SOURCE & DERIVATION

Replenishment and war reserve repair parts are procured for every year following the procurement of the initial spares and repairs. The costs is estimated to be 1.95. 60% of the cost is attributed to procurement of repair parts, leaving 40% of the cost to be attributed to the procurement of spare parts. The estimate for the percentage of manufacturing cost that would be required to procure repair and spare parts was based on 75% the amount historically required to sustain the current MIL-STD Diesel Generator sets. This information was taken strictly from Enhanced CGSA program.

C. ASSUMPTIONS

This estimate also includes the cost of procuring war reserve parts as well as the replenishment parts.

5.012 REPLACE SPARES

A. ESTIMATE

% of MFG = (1.95 x .40) = .78

B. SOURCE & DERIVATION

Same as 5.011.

5.013 WAR RESERVE REPAIR PARTS

These costs are included in the estimate for the replenishment repair parts.

5.014 WAR RESERVE SPARES

These costs are included in the estimate for the replenishment spare parts.

5.02 PETROLEUM, OIL AND LUBES

A. ESTIMATE

Fuel cost = $ .65
Fuel rate = .09 gallons/kWH
Lube Factor = 1.08

B. SOURCE & DERIVATION

The fuel cost at rated load was multiplied by .7 to find the approximate fuel consumption at 50% load. This value was used to calculate the fuel costs. The fuel consumptions were taken from the PD. It was assumed that at 50% load the fuel consumption would be 70% of the consumption at rated load. It was also assumed that the set would operate on the average at 50% of rated load. Ms. Janet Garrison (4270) provided the fuel cost and lubrication factors. The annual operating hours for the set were provided in the ROC.

5.03 AMMUNITION

No ammunition is required for this project.

5.04 DEPOT MAINTENANCE

5.041 CIVILIAN LABOR

A. ESTIMATE

Civilian labor rate = .03385
# of units overhauled = 1656

B. SOURCE & DERIVATION

Civilian labor rate also includes the general administrative expenses and indirect expenses associated with the maintenance manhour. The number of units to be overhauled includes all sets except the training sets. In the calculation of the number of overhauls, a constant factor of .5 was subtracted to account for the fact that by using a fractional overhaul rate the worst possible case is calculated. The constant factor was subtracted to better estimate the real costs. This method is supported by the actual definition of a mean. Estimates of MTTO of the set are given in the PD. The estimates of civilian labor rates, indirect expenses and general administrative expenses associated with the overhaul were provided by the Enhanced CGSA program.

C. ASSUMPTIONS

It is assumed that the training sets will never undergo overhaul due to the nature of their use.

5.042 <u>MATERIELS (OM)</u>

A. ESTIMATE

% Unit MFG = (2.9 x .60) = 1.74

B. SOURCE & DERIVATION

The depot specific material costs are estimated to be 2.9% of the unit manufacturing cost for the 10kW size. This estimate is based on the historical data for the current MIL-STD Generator sets. Other material costs for overhaul have been included in the estimate for the replenishment spares and repairs. 60% of this cost is attributed to repair parts and 40% is attributed to spare parts. As with the calculation of labor costs a constant factor of .5 is subtracted form the number of overhauls. The estimate here only covers parts that are generally stocked. The estimate of the percentages required for spares and repairs was given by the Enhanced CGSA program.

5.043 <u>MATERIEL (PROC)</u>

A. ESTIMATE

% Unit MFG = (2.9 x .40) = 1.16

B. SOURCE & DERIVATION

Same as 5.043

5.044 <u>MAINTENANCE SUPPORT ACTIVITY</u>

A. SOURCE & DERIVATION

This estimate includes all direct charges except for direct labor and material cost for overhaul provided by Ms. Janet Garrison.

5.05 <u>FIELD MAINTENANCE CIVILIAN LAB</u>

A. ASSUMPTIONS

Assuming insignificant amounts of field maintenance are done by the civilian laborers. This assumption is based on the results of the most recent sample data collection report.

5.06 TRANSPORTATION

A. ESTIMATE

Wtd Sum of Transportation $ = 1.401294

B. SOURCE & DERIVATION

The number of sets included in all of the sets except the training sets. In all cases, a constant factor of .5 was subtracted from the number of overhauls per set. A 10% packaging factor was applied to the set weights for the packaging materials. The set weight does not include the trailer. Ms. Janet Garrison provided these estimates.

5.07 SYSTEM SPECIFIC REPLACE TRAINING AMMUNITION/MISSILES

A. SOURCE & DERIVATION

Since this cost estimate is to be used to compare with program costs of other generators, these costs have not been included here. It is assumed that regardless of the generator set program, the sustainment training costs shall remain the same.

5.08 MILITARY PERSONNEL

5.081 CREW PAY & ALLOWANCE

No crew assigned to this project.

5.082 MAINTENANCE PAY & ALLOWANCE

A. ESTIMATE

Wtd Sum Base P&A = $ 128,602.08
Unit MFG $ = 12,630

B. SOURCE & DERIVATION

The weighted sum of base pay and allowance was taken from the Enhanced CGSA program. The training sets were excluded from this calculation because they do not undergo normal repair. The current pay scale was provided by Ms. Janet Garrison was also taken from Enhanced CGSA program.

5.083 SYSTEM SPECIFIC SUPPORT PAY & ALLOWANCE

No additional support personnel are known to exist.

5.084 TRAINEE/TRAINER PAY & ALLOWANCE

No additional trainers or trainees are known to exist.

5.085 SYSTEM/PROJECT MANAGEMENT PAY & ALLOWANCE

No system specific project management after initial fielding of the generator kit.

5.086 PERMANENT CHANGE OF STATION (PCS)

A. ESTIMATE

Wtd Sum of PCS = $ 5178.12468
Unit MFG $ = 12,630

B. SOURCE & DERIVATION

Ms. Janet Garrison provided the weighted sum of PCS costs. The number of sets used in this calculation did not include the training sets. The generator set distribution was based on the distribution of the current fleet. It was assumed that no maintenance manyears were associated with the training sets due to the nature of their use.

5.087 OTHER MPA FUNDED SUSTAINMENT

No other MPA funded sustainment at this time.

5.09 SYSTEM/PROJECT MANAGEMENT (CIVILIAN)

No system specific project management after initial fielding of the generator sets.

5.10 MODIFICATIONS/KITS

No modifications or kits planned at this time.

5.11 OTHER SUSTAINMENT

5.111 OTHER O&M FUNDED SUSTAINMENT

A. ESTIMATE

Wtd Sum of QMU = $ 29,891.236
Unit MFG $ = 12,630

B. SOURCE & DERIVATION

Ms. Janet Garrison provided the weighted sum of QMU costs. The number of sets used in this calculation did not include the training sets. The QMU includes other indirect costs, utilities, military and maintenance, base operations, and central supply costs.

5.112 OTHER PROCUREMENT FUNDED SUSTAINMENT

No other procurement funded sustainment at this time.

APPENDIX M

PURCHASE DESCRIPTION

PURCHASE DESCRIPTION

10KW SIGNATURE SUPPRESSED

LIGHTWEIGHT ELECTRIC ENERGY PLANT
(SLEEP)

DRAFT

20 November 1987

Prepared For:

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

PURCHASE DESCRIPTION

GENERATOR SET, TACTICAL, QUIET

10 KW

1. SCOPE:

1.1 Scope. This purchase description covers the requirements for quiet tactical generator set (hereinafter referred to as "set") of 10 kiloWatts.

1.2 Classification. The sets shall be type I (Tactical), Class 2 (Utility).

1.3 Modes. The set shall be of the following modes:

(a) Mode II - 400 Hz.
(b) Mode III - 60 Hz.
(c) Mode IV - DC.

1.4 Set rating. The sets shall be rated for each of the modes as follows:

(a) Mode II - 10 kW; 0.8 power factor, lagging; 120/208 V, three phase, 4 wire reconnectable to 120/240 V, single phase, 3 wire and 120 V, single phase, 2 wire.

(b) Mode III - 10 kW; 0.8 power factor, lagging; 120/208 V, three phase, 4 wire reconnectable to 120/240 V, single phase, 3 wire and 120 V, single phase, 2 wire.

(c) Mode IV - 10 kW; 28 Vdc, 357 amperes, 2 wire.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this Purchase Description to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

O-A-548D	12-Jan-1970	Antifreeze/Coolant, Engine, Ethylene Glycol, Inhibited, Concentrated.
O-I-490A	19-Jun-1973	Inhibitor, Corrosion, Liquid Cooling System.
W-R-550A	18-Aug-1977	Rod, Ground (With Attachments).
QQ-P-416E	27-Feb-1987	Plating, Cadmium (Electrodeposited).
VV-F-800C	26-Jul-1985	Fuel Oil, Diesel.
ZZ-B-190A	13-Nov-1981	Belts, V, Engine Accessory Drive.
FED-STD-H28	28-Aug-1985	Screw Thread Standards for Federal Services.
Forest Service Standard 5100-1a		Spark Arresting Exhaust Systems.

MILITARY

MIL-T-704J	28-May-1985	Treatment and Painting of Material.
MIL-E-917D	16-Dec-1966	Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-L-2104D	01-Apr-1983	Lubricating Oil, Internal Combustion Engine, Tactical Service.
MIL-L-2105C	08-Apr-1981	Lubricating Oil, Gear, Multi Purpose.
MIL-S-3950F	14-Feb-1976	Switch, Toggle, Environmentally Sealed, General, Specification For.
MIL-W-5088K	28-Dec-1984	Wiring, Aerospace Vehicle.

MIL-H-5606E	02-Mar-1984	Hydraulic Fluid, Petroleum Base, Aircraft Missile, and Ordnance.
MIL-T-5624L	10-Aug-1983	Turbine Fuels, Aviation, Grades JP-4 and JP-5.
MIL-H-6083E	14-Aug-1986	Hydraulic Fluid, Petroleum Base.
MIL-A-8421F	25-Oct-1974	Air Transportability Requirements, General Specifications For.
MIL-W-8777C	11-Apr-1968	Wire, Electrical, Silicone Insulated, Copper.
MIL-E-10062E	14-Aug-1986	Engine, Preparation for Shipment and Storage of.
MIL-G-10924D	13-Jun-1983	Grease, Automotive and Artillery.
MIL-A-11755D	21-Aug-1981	Antifreeze, Arctic-type.
MIL-C-16173D	19-Nov-1968	Corrosion Preventive Compound, Solvent Cutback, Cold-Application.
MIL-S-19500G	03-Mar-1986	Semiconductor Device, General Specification For.
MIL-L-21260C	11-Feb-1981	Lubricating Oil, Internal Combustion Engine, Preservative and Break-in.
MIL-G-28554B	14-Sep-1983	Generator Set, Mobile Electric Power and Supplemental Equipment Packaging of.
MIL-M-38510F	07-Nov-1986	Microcircuits, General Specification for.
MIL-I-46058C	08-Nov-1982	Insulating Compound, Electrical (For Coating Printed Circuit Assemblies).
MIL-A-46153B	17-Mar-1981	Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package.
MIL-F-46162C	12-Nov-1985	Fuel, Diesel, Reference Grade.
MIL-L-46167A	07-Jan-1985	Lubricating Oil, Internal Combustion Engine, Arctic.
MIL-A-52363B	17-Jan-1983	Air Cleaners, Intake: Dry-Type (For Internal Combustion Engine).
MIL-W-81044B	31-Dec-1973	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulation, Copper or Copper Alloy.
MIL-T-83133A	04-Apr-1980	Turbine Fuel, Aviation, Kerosene, Grade JP-8.

MIL-STD-105D	29-Apr-1963	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-130F	21-May-1982	Identification Marking of US Military Property.
MIL-STD-195	07-Feb-1958	Marking of Connections for Electrical Assemblies.
MIL-STD-199C	28-Aug-1981	Resistor, Selection and Use of.
MIL-STD-275E	31-Dec-1984	Printed Wiring for Electronic Equipment.
MIL-STD-454K	14-Feb-1986	Standard General Requirements for Electronic Equipment.
MIL-STD-461C	04-Aug-1986	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	31-July-1967	Electromagnetic Interference Characteristics, Measurement of.
MIL-STD-633E	22-Feb-1980	Mobile Electric Power, Engine Generator, Standard Family, General Characteristics.
MIL-STD-705B	26-Jun-1972	Generator Sets, Engine-Driven, Methods of Tests and Instructions.
MIL-STD-810D	19-Jul-1983	Environmental Test & Engineering Guidelines.
MIL-STD-882B	30-Mar-1984	System Safety Program Requirements.
MIL-STD-889B	07-Nov-1979	Dissimilar Metals.
MIL-STD-1400B	19-Dec-1975	Engine, Gasoline or Diesel, Methods of Test.
MIL-STD-1472C	02-May-1981	Human Engineering Design Criteria for Military Systems, Equipment and Facilities.
MIL-STD-1474B	10-Oct-1980	Noise Limits for Army Material.
MS-25331C	01-Feb-1985	Light Assembly, Press to Test Indicator.
MS-5471C	06-Jan-1969	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200 Deg. C, Polyester Jacket.
MS-35000P	11-Jan-1984	Battery, Storage, Lead-Acid, Waterproof.
MS-51321D	28-Jan-1986	Pump, Fuel, Electrical, 24 Volts DC70 25 GPH Capacity.

MS-52131	17-Dec-1975	Connectors, Plug, Electrical Intervehicle Power Cable.
MS-52149A	11-Jan-1983	Battery, Storage, Lead Acid, (Low Maintenance).
MS-90725D	02-Jul-1974	Screw, Cap, Hexagon Head (Finished Hexagon Bolt), Steel, Grade 5, Cadmium Plated, UNC-2A.

HANDBOOKS

MILITARY

MIL-HDBK-705B	26-Jun-1972	Generator Sets, Electrical, Measurements and Instrumentation.

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this Purchase Description to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

OTHER

TOP 1-2-610	Human Factors Engineering: Test Procedures.
TOP 1-2-610	Human Factors Engineering: Part II, Guide for Evaluation.
DA Pamphlet No. 700-21-1	The Army Test, Measurement and Diagnostic Equipment (TMDE) Preferred Items List.
DA Pamphlet No. 700-21-1	Nuclear Survivability Criteria for Commercial Generator Sets and Assemblages.
DA Pamphlet No. 700-21-1	NBC Contamination Survivability Criteria for Army Materiel (Revised).

Drawings:

US Army Belvoir Research, Development and Engineering Center

69-539	69-692	69-776
69-561	69-693	69-777
69-651	69-693	70-513
69-662	69-694	72-2459
69-668	69-695	73-0506
	69-774	

(Note: Project Manager-Mobile Electric Power DOD drawings. All Code 30544 Drawings.)

SUPPLY CATALOG

SC 5180-90-CL-N26 HR Department of the Army Supply Catalog, Tool kit, General Mechanic's Automotive.

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this Purchase Description to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified,the issues of documents not listed in the DODISS shall be the issue of the non-Government documents which is current on the date of the solicitation.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

MG1 Motors and Generators.
MG2 Safety Standards for Construction and Grade for Selection.

(Application for copies should be addressed to the National Electrical Manufacturers Association, 155 East 44th Street, New York, NY 10017.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE Handbook of Standards.

(Application for copies should be addressed to the Society of Automotive Engineers,Department 105, 400 Commonwealth Drive, Warrendale, PA 15086.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

MH 3.1 American National Standard Requirements for Round Metal Motor Oil Cans.

Y 32.2 Graphic Symbols for Electrical and Electronics Diagrams.

(Applications for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING and MATERIALS (ASTM)

ASTM E84 Building Materials, Surface Burning, Characteristics of.

ASTM D3951 Standard Practices for Commercial Packaging.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Non-Government standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents may also be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this Purchase Description and the references cited herein, the text of this Purchase Description shall take precedence. Nothing in this Purchase Description, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Description. The set shall be a housed unit consisting of a: brushless generator, excitation system, governing system, fuel system, 24 DC volt cranking system, control system, protection system, an engine that can operate on the fuels specified in (3.11), and all other devices specified herein.

3.2 First article. The contractor shall furnish first article (6.4) model sets in the modes, sizes, and quantities specified (6.2), for inspection/test as specified (4.3 and 4.4) for determination of conformity to this Purchase Description. Any deviation from the requirements of this Purchase Description requires specific written approval from the contracting officer.

3.3 Standard sample. A standard sample model of a the set shall be randomly selected from the first production lot (See 4.4.1) and will remain in place at the contractor's facility for comparison with other production sets. The standard sample model shall be shipped after the last production lot at the direction of the contracting officer.

3.4 Reliability. The set reliability shall be 600 hours Mean Time Between Operational Mission Failure (MTBOMF), the minimum reliability shall be not less than 400 hours MTBOMF.

3.4.1 Life and overhaul requirements. The set shall have a minimum life of no less than 12,000 hours. Overhaul of the set (excluding engine) shall be allowed at no less than 6,000 hours intervals. Overhaul of the engine shall be allowed at no less than 3,000 hour intervals. Replacement of the engine, major engine components, or generator shall not be allowed during overhaul. The set, after overhaul, shall be capable of meeting all requirements specified herein.

3.5 Maintainability. The maintenance ratio (6.3.18) of the set shall not exceed 0.05. All scheduled maintenance at intervals less than 1000 hours shall require a maximum of two hours to perform with one mechanic (MOS-52D). Unscheduled maintenance shall be kept to a maximum of two hours when practical.

3.5.1 Servicing and scheduled maintenance. The minimum interval between scheduled maintenance shall be 12 hours. Except for scheduled maintenance preventative checks and inspections the time between schedule maintenance service (repair, adjustment, replacement,etc.) shall not be less than 250 hours. Injectors, if used, shall not require scheduled maintenance at intervals less than 1000 hours. One person (MOS-52D) shall be able to change the oil and oil filter within 20 minutes. A means to quickly and easily check and add coolant while the set is off shall be provided. A means to quickly and easily check and add oil while the set is running or off shall be provided. A means to bleed the fuel system of air or water with the set running or off shall be provided. The time needed to service

and checkout the set, from shutdown to resumption of power generation, will be a maximum of 30 minutes with a maximum reaction time of 30 minutes at temperatures below -25°F and 15 minutes at temperatures at or above -25°F.

3.5.2 Support equipment. To the extent possible, Test, Measurement, and Diagnostic Equipment (TDME) required for maintenance shall currently exist in the supply system. When required, as much TMDE as practical shall be selected from the TMDE Preferred Items List (DA Pamphlet No. 700-21-1). Sets shall be equipped with a diagnostic connector assembly (DCA) to allow for maintenance interface with the Simplified Test Equipment Internal Combustion Engine (STE-ICE) TMDE. Hydraulic systems shall be designed so all required maintenance can be accomplished with the Hydraulic System Test and Repair Unit (HSTRU). Standard tools in the General Mechanic's Automotive Tool Kit (SC 5180-90-CL-N26-HR; NSN 5180-00-177-7033; LIN W33004) shall be used as much as possible for set maintenance.

3.6 Materials, components, and treatments. Materials, components, and treatments shall conform to accepted industry, federal, or military standards and subject to all provisions of this Purchase Description.

3.6.1 Material deterioration and control. Sets shall be fabricated from compatible metals and materials that are inherently corrosion resistant or are treated to prevent corrosion and deterioration associated with storage and operating environments specified herein.

3.6.1.1 Identification of materials and finishes. The contractor shall identify the specific material, material finish, or treatment for use with components and sub-assemblies and shall provide this information to the Government upon request.

3.6.1.2 Contact of Dissimilar Metals. Dissimilar metals shall not be used in intimate contact with each other unless protected against galvanic corrosion. Dissimilar metals and methods of protection are defined and detailed in MIL-STD-889. The identification of the specific material, material finish, or treatment used for any component or sub-component shall be made available, upon request, to the contracting officer.

3.6.2 Toxic Products. When possible, an alternative nontoxic material shall be chosen. When not possible, the toxic materials contained within the set shall be controlled to present no hazard to operator or maintenance personnel under any condition. Material safety shall be in accordance with FED-STD-313.

3.6.3 Thermal and sound insulating material. Thermal and sound insulating material shall be free from perceptible odors and noxious fumes; fire retardant(flame spread classification of 25 or less by ASTM E 84); unaffected by battery electrolyte or petroleum derivatives; and capable of maintaining its shape, position, and consistency inherently with suitable retaining methods.

3.6.4 Recovered Materials. For this requirement, recovered materials (as distinguished from virgin materials) are defined as materials collected from

solid waste and reprocessed to become a source of raw materials. The components, pieces, and parts incorporated in the set may be newly fabricated from recovered materials to the maximum extent practical, provided the materials, components, and end item meet all other requirements. Used, rebuilt, or remanufactured components, pieces, or parts shall not be incorporated in the set.

3.6.5 Current transformers, DC circuit breakers, limit switches, shunts, relays, knobs, rotary switches, and lugs. Current transformers, DC circuit breakers, limit switches, shunts, relays, knobs, rotary switches, and lugs shall exist in the DOD supply system and shall conform to MIL-SPEC or MIL-STD. Relays shall be totally enclosed (provided with cover) or hermetically sealed. Current transformer secondaries shall be rated 1.0 amp.

3.5.6 Drive belts. Drive belts shall conform to ZZ-B-190. A means shall be provided which permits one person, using only common hands tools, to check and adjust belt tension in 10 minutes.

3.6.7 Capacitors. Capacitors shall be in accordance with MIL-STD-454, Requirement 2. Electrolytic capacitors shall be of the tantalum type.

3.6.8 Toggle switches. Toggle switches shall be of the sealed toggle bushing type conforming to MIL-S-3950, and shall be mounted with the on position up.

3.6.9 Adhesives. Adhesives shall conform to FED-SPEC, MIL-STD, or MIL-SPEC.

3.6.10 Printed circuit boards. Printed circuit (PC) boards shall be fabricated in accordance with MIL-STD-275. The finished PC board and components shall be conformal coated in accordance with MIL-STD-275 using material in accordance with MIL-I-46058. Connections made through PC boards shall be clinched before soldering. All PC boards shall be marked PC (specify) on the board and chassis to indicate the location of PC boards.

3.6.11 Seals. Seals shall be replaceable.

3.6.12 Antiseize material. Antiseize material shall not be used.

3.6.13 Resistors and rheostats. Resistors and rheostats shall conform to MIL-STD-199. All rheostats and potentiometers shall be of the enclosed wire-wound type unless used on circuit boards. Tapped resistors shall not be used.

3.6.14 Hoses, fittings, and clamps. Hoses shall conform to SAE standards. Hose fittings and clamps shall exist in the DOD supply system.

3.6.15 Hinges and latches. Hinges and hinge pins shall be corrosion resistant steel (at least 12 percent chromium). A means shall be provided to prevent workout of the hinge pins. Latches shall require manual, not spring action, for closure. Set access doors shall be flush mounted, non-

key locking, quarter turn from unlatched to fully latched, and shall not require special tools to operate.

3.6.16 Quick-disconnect fasteners. Quick disconnect fasteners shall exist in the DOD supply system and conform to MIL-STD or MIL-SPEC. One quarter (1/4) turn fasteners shall conform to drawings 69-693, 69-694, or 69-695.

3.6.17 Terminal boards and terminal supports. Terminal boards and supports shall exist in the DOD supply system and conform to MIL-STD or MIL-SPEC. Creepage and clearance distance between energized terminals at different potentials shall be as specified in MIL-E-917. Whenever jumpers are required on terminal boards, the items on Drawing 69-651 shall be used except for terminal boards which are an integral part of the printed circuit board.

3.6.18 Connectors. Connectors shall exist in the DOD supply system and conform to MIL-STD or MIL-SPEC. With the connection broken, the female part of the connector shall be the energized element. Right angle plugs shall be used to avoid making sharp bends in wiring harnesses. All connectors shall conform to MIL-STD-1472 (5.9.14).

3.6.19 Wire and cable. All wire and cable shall be stranded, and sized according to the requirement. The conductor number shall be no less than AWG 16, except as follows:

a. Wire in multi-conductor flat cables may be smaller than AWG 16.

b. Wiring located within a hermetically sealed electrical component may be smaller than AWG 16.

c. Wire used in coils and windings and wire used as short jumpers on printed circuit boards may be solid and smaller than AWG 16.

d. Wire size smaller than AWG 16 may be used within electrical enclosures if specific written approval is obtained from the contracting officer.

Generator lead wire shall conform to MIL-W-8777 or MS25471. All other wiring and cable shall conform to MIL-W-81044. Wire and cable shall have a white jacket for the outer covering. Each wire, except in multi-conductor flat cables, shall be identified at intervals of six inches or less and at each termination with numbering agreeing with the wiring diagram or schematic. Wiring in DC circuits, except battery cables, shall be identified by wire number stamped in red color. Wiring in AC circuits shall be identified in accordance with MIL-W-5088 by wire number stamped in black color.

3.6.20 Integrated circuits. Integrated circuits shall conform to MIL-M-38510.

3.6.21 Semiconductor devices. All semiconductor devices shall conform to MIL-S-19500 JANTX and shall be of the hermetically sealed silicon type.

Except for Zener diodes and as otherwise specified herein, all semiconductor devices shall have repetitive voltage rating not less than three times the peak repetitive voltage to which they will be subjected in the set. They shall also have a current rating not less than 200 percent of the maximum DC current which they carry when installed in the set, ignoring transients. Diodes or controlled rectifiers used to supply DC power to the alternator main field shall save a peak inverse voltage rating of not less than ten times the normal alternator field voltage (DC field voltage at rated load and generator stabilized at normal operating temperature). In addition, all semiconductor devices shall be capable of withstanding (or being protected against) transient voltage and current peaks as may be experienced during all tests specified herein including: short circuit (single or three phase) at the set terminals, application of half per unit load at the set terminals, motor starting and actuation of the overvoltage protection device through an actual overvoltage condition of the set. Circuits which require semiconductor devices of selected, matched, or paired characteristics shall not be allowed.

3.6.22 Hardware. Different types and sizes of hardware shall be kept to a minimum. Fastener threads shall conform to FED-STD-H28 and shall be as specified herein. Paragraphs 3.6.22.1 and 3.6.22.2 need not apply to components furnished as a standard part of the engine assembly. If metric fasteners are provided on other assemblies, they need not conform to the non-applicable portions of paragraph 3.6.22.2.

3.6.22.1 Pipe and Fittings. Pipe and fittings shall conform to SAE standards and shall be made of suitable corrosion resistant material unless otherwise specified herein.

3.6.22.2 Fasteners (except electrical). Each fasteners (screw, stud, bolt, pin, etc.) shall be equipped with a locking device to prevent loosening due to vibration. Locking shall be by locknuts, castellation nuts with cotter pins, lockwashers, lockwire, or lockplate. No swagging, peening, or staking of parts subject to removal or adjustment, with the exception of hinge pins, shall be permitted. Lockwashers, other than those on the engine and engine accessories, shall be captive on nuts, machine screws, and bolts, when normal size is 1/4-inch and less in diameter. Drawings 69-561 and 69-662 govern nut and captive washer, and screw and captive washer, respectively. All bolts, cap screws, and machine screws nominal size greater than 1/4-inch shall be in accordance with MS-90725. All machine screws and bolts without captive washers in sizes 8, 10, 12, and 1/4-inch shall be hexagon headed and slotted. Self-locking toothed lockwashers shall be used where necessary for thermal changes. Unused length of threads of studs or bolts shall not exceed half the diameter of the stud or bolt.

3.6.22.3 Sheet metal screws and rivets. Sheet metal screws shall not be used. Rivets shall not be used except for laminated generator sub-assemblies and sheet metal off-the-shelf commercial components.

3.6.22.4 Blind hardware. A nut located such that it cannot be grasped by the thumb and forefinger of one hand and by a common tool shall be caged, or some equivalent means shall be used eliminate handling the nut during

removal or assembly. Physical access of uncaged nuts shall be in accordance with Figure 37 of MIL-STD-1472.

3.6.22.5 Fasteners (electrical). Lock devices shall be provided for each fastener used in making an electrical connection. Each fastener, locking device, or other hardware (washers, etc.) shall be made of corrosion resistant metal or shall be treated to corrosion resistant by cadmium plating in accordance with QQ-P-416, class 1, type II. Fasteners (bolts, screws, studs, etc.) shall not be required to carry current; they shall serve merely to hold current-carrying parts (lugs, terminals, etc.) in firm contact with each other. Where flow of current through a stud cannot be avoided, the stud and all its associated hardware (nuts, locking devices, washers, etc.) shall be made of corrosion resisting material. Positive locking devices (washers, etc.) shall be made of corrosion resisting material. Positive means (such as pins or square shanks) shall be provided to prevent turning of studs in their mountings when nuts are tightened or loosened; lockwashers which depend on friction or spring action will not be acceptable for this purpose. Unused length of threads of studs or bolts shall not exceed half the diameter of the stud or bolt.

3.7 Aural and thermal signatures.

3.7.1 Aural Signature.The SLEEP set will emit no detectable aural signature at 100 meters. Non-detectability is defined by sound pressure levels and octave bands contained in MIL-STD-1474. To protect the hearing of personnel working on or near the set, noise levels in excess of those described in Category D of MIL-STD-1474 shall not be emitted.

3.7.2 Thermal Signature. The thermal image of SLEEP will not be more than +/- 4°C from background temperature with over 90% of the surface exposed. Thermal image will be measurable from representative PAVE TACK type FLIR at 4000 meters.

3.8 Electrical performance. Set electrical performance shall be as specified herein. Components of the set shall not be damaged when the set is operated continuously at all possible frequency and voltage adjustments obtainable by controls. The set shall provide rated load at the output terminals under all operating conditions specified herein.

3.9 60 Hz or 400 Hz operation.

3.9.1 Frequency performance.

3.9.1.1 Frequency regulation. Frequency regulation (6.3.23) shall not exceed 3 percent.

3.9.1.2 Frequency short-term stability (30 seconds). At every constant load from no load to rated load, the frequency shall remain within a bandwidth equal to 2 percent of rated frequency. Repetitive periodic variations, even though within the allowable bandwidth, shall not be permitted.

3.9.1.3 Frequency long-term stability (4 hours). At constant ambient temperature, constant barometric pressure, constant voltage, and any constant load (from no load to rated load) the frequency shall remain within a bandwidth equal to 3 percent of rated frequency for a 4-hour operating period.

3.9.1.4 Frequency transient performance. Following any sudden increase in load, including from no load to rated load, the frequency shall reach stable conditions (6.3.8) within 4 seconds, and the maximum transient frequency change below the new steady-state frequency (undershoot, 6.3.24) shall not be more than 4 percent of rated frequency. Following any sudden decrease in load, including from rated load to no load, the frequency shall reach stable conditions within 6 seconds, and the maximum transient frequency change above the new steady-state frequency (overshoot, 6.3.24) shall not be more than 4 percent of rated frequency.

3.9.1.5 Frequency adjustment range. The minimum frequency adjustment range shall be +3 percent of rated frequency. It shall not be possible to adjust frequency to a valve which actuates the overspeed protective device.

3.9.2 Voltage performance.

3.9.2.1 Voltage unbalance. For three phase connections the maximum difference between line to line voltages shall not exceed 5 percent of rated voltage under the condition of a single phase, line-to-line, unity pf load (resistive) of 25 percent of rated current with no other load on the set.

3.9.2.2 Phase balance (voltage). For three phase connections the maximum difference in the three line-to-neutral voltages under open circuit at rated voltage and frequency shall not exceed 1 percent of rated line-to-neutral voltage. The maximum difference between the voltages of the 120-volt windings of any one phase shall not be more then 1 volt.

3.9.2.3 Voltage waveform. The deviation factor of the line-to-neutral and line-to-line voltages at rated load at 0.8 pf, rated load with unity pf, and no load shall not exceed 6 percent. The deviation factor shall not exceed 5 percent in the 3 phase, 120/208 volt connection. Single frequency harmonics shall not exceed 3 percent in the single phase connections and 2 percent in the 3 phase, 120/208 volt connection. There shall be no evident discontinuities, spikes, or notches in the waveform.

3.9.2.4 Voltage regulation. Voltage regulation (6.3.23) shall not exceed 3 percent.

3.9.2.5 Voltage short-term stability (30 seconds). With all possible constant loads (from no load to rated load), the voltage at the set terminals shall remain within a bandwidth equal to 2 percent of rated voltage.

3.9.2.6 Voltage long-term stability (4 hours). At constant ambient temperature, constant barometric pressure, constant frequency, and at all

possible constant loads (from no load to rated load), the voltage shall remain within a bandwidth of 4 percent of rated voltage.

3.9.2.7 Transient performance.

a. With the set initially operating at no load, rated voltage, and rated frequency,the rms terminal voltage of the set shall not drop to less than 60 percent of no load voltage (rated voltage) when a balanced three-phase 0.4 pf or less (lagging) static load having an impedance of 0.5 per unit is suddenly applied to the set output terminals. When connected to the specified load, the output voltage shall recover to a minimum of 95 percent of rated voltage within 5.0 seconds, and shall stabilize at or above this voltage.

b. When the set is initially operating at rated frequency, rated voltage, and following any sudden change in load from no load to rated load, the instantaneous rms voltage shall not drop to less than 80 percent of rated voltage and shall reach stable conditions within 3 seconds; no overshoot or undershoot (6.3.24) of the final voltage may exceed the initial voltage transient in amplitude. The above requirements shall also apply when the load is suddenly changed from rated load to no load, except that the initial voltage transient shall not exceed 130 percent of rated voltage.

c. The generator set shall be capable of across-the-line starting a motor rated at 1.0 horsepower per kW rating (4.7.8) under all conditions specified herein.

3.9.2.8 Voltage adjustment range. The minimum voltage adjustment range shall be -5 to +10 percent of rated voltage.

3.10 DC operation.

3.10.1. Speed (RPM) performance.

3.10.1.1 Speed (RPM) regulation. Frequency regulation (6.3.23) shall not exceed 3 percent.

3.10.1.2 Speed (RPM) short-term stability (30 seconds). At every constant load (from no load to rated load), the frequency shall remain within a bandwidth equal to 2 percent of rated frequency. Repetitive periodic variations, even though within the allowable bandwidth, shall not be permitted.

3.10.1.3 Speed (RPM) long-term stability (4 hours). At constant ambient temperature,constant barometric pressure, constant voltage, and any constant load (from no load to rated load) the frequency shall remain within a bandwidth equal to 3 percent of rated frequency for a 4-hour operating period.

3.10.1.4 Speed (RPM) transient performance. Following any sudden increase in load (from no load to rated load), the frequency shall reach stable conditions (6.3.8) within 4 seconds, and the maximum transient frequency

change below the new steady-state frequency (undershoot, 6.3.24) shall not be more than 4 percent of rated frequency. Following any sudden decrease in load, including from rated load to no load, the frequency shall reach stable conditions within 4 seconds, and the maximum transient frequency change above the new steady-state frequency (overshoot, 6.3.24) shall not be more than 4 percent of rated frequency.

3.10.1.5 Speed (RPM) adjustment range. The minimum frequency adjustment range shall be +3 percent of rated frequency. It shall not be possible to adjust frequency to a valve which actuates the overspeed protective device.

3.10.2 Voltage performance.

3.10.2.1 Voltage regulation. Voltage regulation (6.3.23) shall not exceed 3 percent.

3.10.2.2 Voltage stability . With all possible constant loads (from no load to rated load), the voltage at the set terminals shall remain within a bandwidth equal to 2 percent of rated voltage.

3.10.2.3 Transient performance. When the set is initially operating at rated frequency, rated voltage, and following any sudden change in load (from no load to rated load), the instantaneous rms voltage shall not drop to less than 70 percent of rated voltage and shall reach stable conditions within 2 seconds.

3.10.2.4 Voltage adjustment range. The minimum voltage adjustment range shall be 23 to 35 volts at normal operating temperatures and ±5 percent of rated voltage at extreme temperatures.

3.10.2.5 DC output voltage. The following limits, when measured at the output terminals, shall not be exceeded at any load (from no-load to rated load) over the voltage adjustment range specified herein:

a. Ripple amplitude (6.4.15) 1.5 V maximum.

b. Distortion factor (6.4.16) 0.0035 maximum.

c. Distortion spectrum (6.4.18) see Figure 1 for limit.

3.10.2.6 Voltage Drift. With the set operating at constant load and with a change in ambient temperature of 60°F in an eight hour period (set temperature stabilization being accomplished at both the initial and final ambient temperature conditions), the output voltage shall not change by more than two percent of the rated voltage. This requirement shall also be met as the set stabilizes from cold conditions at all constant loads from no load to rated load.

3.11 Starting, stopping, and operating.

3.11.1 Starting. The set shall start (6.3.3) within 5 minutes at each of the following conditions or any possible combination of the following conditions:

a. At ambient temperatures from 120°F to -50°F at sea level and all possible relative humidity.

b. At altitudes up to and including 5,000 feet and 95°F.

c. With the base of the set in planes from level to up to 15 degrees from level.

d. With 12 ±1 inches of rain per hour impinging on the set at angles from the vertical up to 45 degrees from the vertical.

e. With up to 355 British thermal units per square foot per hour of solar radiation.

f. With a sand/dust particle concentration of up to 1400 mg per cubic meter. Particle sizes shall range from less than 74 micrometers in diameter to 1000 micrometers, with the bulk of the particles ranging in size from 74 to 350 micrometers.

g. With a snowfall rate of up to 2 inches per hour for 12 hours.

h. With a steady wind speed of up to 73 feet per second and gusts up to 95 feet per second at a height of 10 feet above ground level.

i. With accommodations of ice glaze, freezing rain and hoarfrost of up to 1/2-inch and up to a specific gravity of 0.9.

j. In a salt fog or sea spray environment.

k. With fuels, lubricants, hydraulic fluids, and coolants conforming to (3.11).

3.11.2 Stopping. The set shall stop (6.3.4) within the time interval recommended by the manufacturer.

3.11.3 Operating. Immediately after starting the set may run at no load for 15 minutes (maximum one time warm-up period). At the end of the initial warm-up period (if warm-up is required), the set shall operate for 3,000 hours without critical failure (6.3.5) at all loads, continuous and intermittent, up to and including rated load under all of the conditions or combination of conditions specified in 3.11.1.

3.11.4 Winterization kit. The set shall start and operate as specified herein at ambient temperatures from -25°F to -50°F with winterization kits (6.2) as follows:

a. Within 60 minutes, with use of an external fuel burning winterization kit for a maximum of 55 minutes. External batteries not warmer than -25°F, identical to those provided in the set, are allowed for use only during the cranking cycle.

b. Within 5 minutes after a 24-hour period of standby operation using the fuel burning winterization kit and the external batteries allowed (3.10.A).

c. With use of a 205 to 240 volt, 60 Hz, single phase integral electric winterization kit, after 24 hours of standby operation, the set shall start and accept 75 percent of rated load within 20 seconds. External batteries specified (3.10.A) may be used if required.

Provisions to control, monitor, attach and operate the winterization kit shall be provided with kits.

3.12 Fuels, lubricants, hydraulic fluids, and coolants.

3.12.1 Fuels. The set shall operate using diesel fuel which conforms to MIL-F-46162 or DF-1, DF-2, or DF-A; diesel fuel conforming to VV-F-800 (DF-2, DF-1 or DF-A); or JP-8 turbine fuel conforming to MIL-T-83133. The set shall meet all requirements herein while operating on JP-4 turbine fuel conforming to MIL-T-5624 with a cetane rating of 30 to 35. However, rated load may be reduced 15 percent, at which time a maximum of 300 hours of operation on JP-4 per 3,000 hours of set operation shall be required.

3.12.2 Lubricants. The set shall operate on engine lubricating oil conforming to MIL-L-2104 and MIL-L-46167.

3.12.3 Hydraulic Fluids. If hydraulic fluid is required, the set shall be capable of operating with MIL-H-5606 and MIL-H-6083 hydraulic fluid.

3.12.4 Coolant. If the set includes a liquid-cooled engine, the engine shall be capable of operating with the following coolants:

a. Diluted MIL-A-11755 anti-freeze from -50°F to 120°F ambient.

b. Water with O-A-548 anti-freeze or MIL-A-46153 inhibited anti-freeze from -40°F to 120°F ambient.

c. Water with O-I-490 inhibitor from 40°F to 120°F ambient.

3.13 Engine.

3.13.1 Timing marks. Timing index marks, if used, shall be accessible by one person in 20 minutes.

3.13.2 Lubricating system. The set shall meet all requirements herein using lubricants specified (3.12.2). The lubricating system shall include seals, gaskets, and bearing clearances to permit use of arctic lubricating

oil conforming to MIL-L-46167. The lubricating system shall be compatible with MIL-L-21260 preservative oil. Oil temperature in the oil sump shall stabilize between 100°F and 250°F under all operating conditions specified herein. An oil-drain assembly, consisting of flexible hose assembly and shut-off valve, shall be installed to allow complete drainage of the crankcase/oil-sump outside of the skid base into a suitable container. The oil-drain opening shall have sufficient depth to permit seating of a flexible hose assembly pipe fitting in accordance with SAE standards. Piping, valves, fittings, and tubing of the lubricating system shall have the ability to be disconnected from each other and easily accessible for maintenance. The oil filler opening shall permit oil filling from a standard gallon can conforming to ANSI MH 3.1 clearances. The oil-level bayonet gage shall be marked to accurately indicate full and low oil levels, with the set in a level position while engine is stopped. The bayonet gage shall be placed in a readily accessible location and shall be installed so that no oil leakage occurs under all conditions specified herein. The volume of oil indicated between the "LOW" and "FULL" marks on the dipstick (bayonet gage) shall be sufficient to permit a minimum of 24 hours of operation without requiring the addition of oil. A captive filler cap shall be provided except in the case where the cap and dipstick are of an integral design. The engine shall operate in planes from level to 15 degrees from level and with the oil level at the "LOW" mark on the dipstick when measured with the set in a level position. A full flow oil filtration system shall be provided. Marking shall be provided at the fill port and oil drain in accordance with MIL-STD-1472 (5.9.5).

3.13.3 Manual turning. If necessary, provision shall be made to permit manual turning of the engine crankshaft and associated parts so that inspection and maintenance of parts requiring reference to the crank angle can be made with the set fully assembled. Manual turning by baring on the flywheel ring gear, the generator coupling, or the generator fan is not permitted.

3.13.4 Exhaust system. The exhaust system shall have a spark arresting capability in compliance with Forest Service Standard 5100-1a. Exhaust gases shall not re-enter the set. A means of preventing rain from entering the exhaust system shall be provided.

3.13.5 Cooling system. If a liquid-cooled engine is used, provisions to drain the coolant outside of the skid base into a suitable container shall be provided (MIL-STD-1472, 5.4.1.2.4 and 5.5). The radiator cap shall be captive and not interfere with the radiator fan.

3.13.6 Starting aids. The engine shall be equipped with starting aids if necessary to meet starting and operating requirements specified herein. If ether is used the starting aid system shall include the components described by Drawings 69-777 and 70-513. They shall be permanently installed in each set in a location that shall permit installation and removal of the ether tank shown on Drawing 69-776 without the use of tools. Operation of the ether system shall be automatic upon cycling of a single electrical switch located on the control panel. An electrical interlock shall be provided such that the ether starting aid will be inoperative unless its switch is

activated concurrently with cranking of the engine. The ether tank shall not be a component of the set and shall be furnished only as required to support Section 4 testing. If ether is used the starting aid system shall not be required for set starting at temperatures at or above 20 F.

3.13.7 Cranking system. The set shall have a 24 - volt (nominal) cranking system for starting and control power as described herein. The cranking system consists of a cranking motor, start solenoid, batteries, battery retainer, slave receptacle, battery charging system, and sufficient relays, connectors, switches, and cables to make a complete system. The system shall have a negative ground. After starting the set shall be capable of operating with batteries removed.

3.13.7.1 Batteries. Batteries shall be shipped charged and dry. Insulation boots shall be installed over battery terminals. The batteries shall have sufficient capacity to permit fulfillment of the following requirements under all conditions between 120°F and -25°F ambient temperatures:

> After two consecutive cranking cycles, each comprising 15 seconds of continuous cranking followed by a 5-second rest period, on an inactive set (engine shut-off, solenoid de-energized) the batteries shall have sufficient reserve to permit normal start of the set.

The set shall start and operate as specified herein with MS35000 and MS52149 batteries. MS35000 batteries shall be furnished with the first article sets. If specified (6.2) batteries shall be furnished with production sets. Production set batteries shall be of the type specified herein (MS35000, MS52149).

3.13.7.2 Battery cable. The positive cable shall have a red sleeve at both ends. Battery terminal connectors shall be provided on one end of each cable (both ends of battery interconnecting cables, if used). Battery cable shall be marked to indicate polarity: "+", or "-".

3.13.7.3 Polarity reversal. The set or any component of the set shall not be damaged (6.3.17) in any manner, if the polarity of battery cables are reversed. It shall not be possible to crank the set with battery polarity reversed.

3.13.7.4 Battery retainer. Means shall be provided to retain the batteries within the set during all transportation and handling and shall be of a type which will permit easy removal of the batteries. The retainer shall be resistant to battery electrolyte. Means shall be provided to allow drainage of any spilled electrolyte out of the set without contact with any set component except the retainer. The battery retainer and batteries shall be such that access to the batteries for maintenance, removal and test is in accordance with MIL-STD-1472, Figure 45.

3.13.7.5 Starting system. The starting system shall have the capacity for cranking the engine at a speed high enough to start within the range of

temperatures and environmental conditions specified herein. The starter duty cycle shall be as recommended by the manufacturer.

3.13.7.6 NATO slave receptacle. A receptacle conforming to MS52131 with cover shall be mounted in a mechanically protected position on the engine end of the set, and shall be connected in parallel with the batteries.
3.13.7.7 Battery charging system. The battery charging system shall have temperature compensating characteristics compatible with the set batteries. The battery charging system shall not be damaged by continuous application of a short circuit or open circuit to its output. The battery charging system should have an upper adjustment range limit of 32 +.5V at -50°F while producing 10 amps.

3.14 Fuel system. The fuel system shall include all necessary pumps, fuel filters, fuel strainers, water separators, fuel tanks, selector valves, piping, fittings, and mounting provisions. All components of the fuel system shall operate satisfactorily without adjustment, under all environmental conditions, with the fuels specified herein. Where applicable, all assemblies shall have their inlet and outlet connections permanently marked. They shall be provided with an accessible drain valve located on the bottom of their canisters. They shall be properly labelled.

3.14.1 Fuel pumps. When fuel pumps are required to transfer fuel from the fuel tank to the fuel system, the pumps shall conform to MS 51321-2.

3.14.2 Fuel filters. The set shall be provided with fuel filters with sufficient filtration capacity to allow for continuous set operation on fuel containing 15 milligrams of AC fine test dust per liter of fuel for a minimum of 250 hours.

3.14.3 Fuel strainers. The set shall be provided with fuel filters with sufficient filtration capacity to allow for continuous set operation on fuel containing 15 milligrams of AC fine test dust per liter of fuel for a minimum of 250 hours.

3.14.4 Water separators. The set shall be provided with a water separator capable of removing fuel/water emulsions and free water from the fuel. The water separators shall not be damaged by freezing of accumulated water within the separator.

3.14.5 Fuel tank. A fuel tank shall be located within the set housing. It shall be located in a manner which will not allow spills or overflows to run into the engine, exhaust, or electrical equipment. It shall be readily removable from the set. Plastic threads shall not be used for fuel line connections. The set fuel tank capacity shall enable eight hour continuous operation on all specified fuels (3.11.1) at rated output when the skid base is level. A fuel spout shall be provided to prevent spillage of fuel onto the set during filling. Filling shall not require the opening of any door. The set shall be constructed to permit filling the tank and operation of the set when the set is inclined from level to 15 degrees from level. A fuel drain and drain valve will allow the emptying of any fuel and tank sediment into a container without requiring tank removal. The fuel drain shall

terminate with a brass, external thread, 1/2 - 20 SAE J514 flared fitting, with captive cap in accordance with DoD Drawing No. 69-539-2. All fuel shall drain outside of the skid base. The inlet of the fuel pickup shall be not less than 1/2-inch from the bottom of the fuel tank and the inlet end of the fuel pickup shall be cut off at an angle or v-shape. The fuel filler shall be positioned to allow filling the tank from a 5 gallon fuel can. The fuel neck opening shall be 3 9/16 inches diameter. The fuel filler shall have a removable fuel strainer attached to the filler with a chain of sufficient length to permit removal for cleaning. The fuel cap shall be vented. The tank and fuel system shall meet the transport and handling requirements specified herein.

3.14.6 Fuel lines. Fuel lines projecting through metal apertures shall be protected by grommets and secured to framing members. Cushioned clips, braces, or brackets shall be used to securely fasten all piping between the tank and the engine. All high-pressure fuel lines shall be made of steel. Hose conforming to SAE standards may be used for low-pressure fuel lines, except hose within a 10 inch distance to the engine exhaust system shall have a metal shield. All low-pressure fuel lines shall be terminated with SAE standard flared-type fittings. All pipe threads shall be treated with a currentlyt existing MIL-SPEC type sealing compound (3.1.2)

3.14.7 Auxiliary fuel line. An auxiliary fuel line conforming to DoD Drawing No. 69-668 and labeled "Auxiliary Fuel Line" shall be provided with all sets.

3.14.8 Float assembly. A float assembly integral with the fuel tank shall be provided. The assembly shall operate to stop the set when the level of fuel in the tank reaches that quantity sufficient for a minimum of 4 minutes operation, at rated load on a level surface.

3.14.9 Auxiliary fuel connection. The fitting for connection of an auxiliary fuel line between the set and the external fuel source shall be a brass, external thread, 1/2 - 20 SAE J514 flared fitting, with captive cap in accordance with DoD Drawing No. 69-539-2. The fitting shall be located adjacent to the fuel filler. This valve shall permit selection of the set tank or an external source as fuel supply for the set, at the option of the operator. The set fuel tank and filler neck shall be grounded if necessary to prevent a fire/explosion safety hazard during refueling from a can or tanker trucks.

3.15 Air cleaner. An air cleaner conforming to MIL-A-52363 shall be provided. It shall be equipped with a disposable barrier-filter element.

3.16 Governing system. Engine speed shall be controlled by a governing system. The governing system shall be "fail-safe" (6.3.22). Any failure of the governing system shall stop the engine and disconnect the control power.

3.17 Generator. The generator shall be such that it will provide for all the requirements specified herein. The generator shall use insulation recommended by the manufacturer to withstand the temperature rise within the generator.

3.17.1 Short-circuit. The generator, shall withstand for 10 seconds a single-phase line-to-line, single-phase line-to-neutral, and symmetrical three-phase short-circuits when the generator is operated with its excitation system. The DC set shall withstand a 10 second short circuits when operated with its excitation system.

3.17.2 Temperature rise. The temperature rise of the coils, windings, bearings and mechanical parts shall not exceed the value recommended by the manufacturer.

3.17.3 Dielectric strength. Windings shall withstand the following 60 Hz voltages applied for one minute:

a. Generator field and exciter windings - 10 times ceiling voltage, but neither less than 1,500 nor more than 3,500 volts, (applied between windings and ground).

b. Windings energized by the 24-volt DC control, cranking, and battery charging systems - 500 volts, (applied between windings and ground).

c. All others - twice rated voltage plus 1000 volts, (applied between winding and ground, and between windings where applicable).

3.17.4 Generator bearings. For single bearing generators, the generator bearing shall be removable without removing the engine or generator from the set. Generator bearings shall be sealed and permanently lubricated.

3.17.5 Generator windings and leads. The generator leads shall not be smaller than 8 AWG for AC sets and 4/0 for DC sets and shall be brought out of the generator frame through nonabrasive bushings or grommets and then through nonabrasive clamps, block or holders which isolate each lead and hold each lead securely in place. Leads shall be identified in accordance with MIL-STD-195. The clamps, blocks, or holders shall be marked with the identified lead that passes through it.

3.17.6 Generator efficiency. The efficiency of the first article preproduction model generators including excitation systems, shall be measured. The production generator, including excitation system, shall have an efficiency not less than two percent below the average efficiency measured for first article preproduction model prototype sets.

3.17.7 Transient reactance, rated voltage. The direct axis transient reactance shall be measured for first article preproduction model sets. The direct axis transient reactance for production sets shall be not more than one percent above the average measured for first article preproduction model sets.

3.17.8 Negative sequence impedance. The negative sequence impedance shall be measured for first article preproduction model sets. The negative sequence impedance for production sets shall be not more than one percent above the average measured for first article preproduction model sets.

3.18 Excitation system. The exciter system shall be electrically isolated from the rest of the set. All electrical power used by the excitation system shall be supplied by the main generator or by a separate generating device as an integral part of the overall generator. The exciter shall have sufficient ceiling voltage to:

a. Provide for the specified set performance.

b. To cause the set output voltage to rise to at least 135 percent of rated value under no load, hot field, rated frequency conditions at 120°F.

The exciter field current of production sets shall not differ by more than 10 percent from the average exciter field current of the first article model sets under the same test conditions. Exciter field coils of the same polarity and type shall be interchangeable where the field coils are removable.

3.19 Instruments, controls, and other devices. A drip proof control assembly shall be located at the generator end of the set, and except as otherwise specified herein, shall contain all the instruments, controls, and devices necessary to start, operate, and monitor the set. All wires shall enter the control assembly through connectors. The set control panel shall be protected by access doors. The access doors shall be self-supporting in the open position. The control panel shall be hinge mounted to permit swing out of the panel to not less than 90 degrees. The malfunction group shall be mounted in a separate module located adjacent to the control assembly. All wires to the malfunction group (module) shall enter the module through one connector. Instrumentation shall conform to MIL-G-52884. Instruments, controls, and devices as follows shall be mounted on a control panel and shall be divided (spatially separated) into the following groups. Labeling shall be in accordance with MIL-STD-1472 (5.5).

3.19.1 Engine group. The engine group shall consist of instruments compatible with the type engine used and those listed below:

3.19.1.1 Fuel level indicator. A fuel level indicating system with a fuel level probe located in the fuel tank shall be provided to indicate fuel level with the set operating or not. The system shall indicate fuel level with the set not operating when the master switch is in the "ON" position.

3.19.1.2 Battery charging indicator. A meter shall be provided to indicate the charge and discharge rate of the batteries in amperes.

3.19.1.3 Running time meter. This instrument shall be a sealed type and shall register total engine hours up to 9999. The instrument shall not be damaged by being energized from batteries with an output of zero to 32 volts.

3.19.1.4 Master switch. A three-position master switch, with spring return to the center position (from the upper position, only), shall be provided to control the set as follows:

a. First position. This position of the switch shall be marked "OFF" and shall be employed to stop the set. When the switch is in the "OFF" position, all generator set circuits which are energized from the battery shall be de-energized, except the panel lights.

b. Second position. The switch shall be in this position for operation of the generator set. It shall be marked "RUN".

c. Third position. This position shall be marked "START". When the switch is actuated the generator set shall electrically crank, come up to rated speed and voltage, and reach a "ready-to-load" state automatically without any additional actions on the part of the operator. This position shall have spring return to the second (RUN) position upon release of switch.

3.19.1.5 Starting aid control switch. This switch, if required, shall activate any starting aids. Warnings (if needed) shall be provided on or above the starting aid control switch.

3.19.1.6 Panel lights. The engine group shall be provided with at least one shielded panel light, controlled by a switch common with the electrical group panel lights. This and all panel illumination shall conform to MIL-STD-1472 (5.8.2).

3.19.1.7 Emergency shutdown switch. A red emergency stop switch shall be provided. It shall stop the set when pushed. The switch shall be labeled "Emergency Stop - Pull to Reset."

3.19.2 Electrical group. The electrical group shall consist of the devices listed herein.

3.19.2.1 AC Voltmeter. The voltmeter shall be capable of indicating 0-500 volts. The voltmeter shall be capable of withstanding application of 3000 volts DC suddenly applied between the case and the two terminals connected together. This DC voltage shall be applied with both positive and negative polarity with respect to the case.

3.19.2.2 AC Ammeter. The ammeter shall be calibrated to indicate percent of rated current. Full scale shall be a minimum of 133 percent of rated current.

3.19.2.3 DC Voltmeter. The voltmeter shall be capable of indicating 0-50 volts. The voltmeter shall be capable of withstanding application of 3000 volts DC suddenly applied between the case and the two terminals connected together. This DC voltage shall be applied with both positive and negative polarity with respect to the case. Rated voltage, 28 volts, shall be indicated with a green mark.

3.19.2.4 DC Ammeter. The ammeter shall be provided to measure load current. The ammeter shall indicate the absolute value output current. The ammeter shall have a non-linear scale with the upper half of the scale compressed.

Full scale shall be 500 amps. Rated current, 357 amps, shall be indicated with a green mark.

3.19.2.5 Ammeter. A DC ammeter shall be provided to measure battery charging current. The scale shall be 10-0-20 amps, with the portion to the left of zero (10-0) being red and marked "DISCHARGE". The portion to the right (0-20) shall be green and marked "CHARGE".

3.19.2.6 Frequency meter. For AC sets the frequency meter shall consist of an indicator and associated circuit elements. The indicator shall be calibrated in Hertz over the required frequency adjustment range and divisions shall be 0.1 Hz.

3.19.2.7 Ammeter-voltmeter transfer switch. A combination ammeter-voltmeter transfer switch shall be provided and connected to allow measurement of the current in each phase, the three line-to-line voltages, and the three line-to-neutral voltages at the input side of the circuit interrupter. Contacts shall be arranged so that current transformer secondaries are never open-circuited when switching from one position to another. This switch shall be located directly below the ammeter and voltmeter (ammeter to the left and voltmeter to the right). An ammeter-voltmeter transfer switch is not required on DC sets.

3.19.2.8 AC circuit interrupter actuator switch. A three-position spring-return to center switch shall be provided to permit opening and closing of the AC output circuit interrupter. The upper position shall be marked "CLOSED" and the lower position shall be marked open.

3.19.2.9 AC circuit interrupter indicator. A press-to-test indicator light with amber lens shall be provided and connected to energize when the AC output circuit interrupter is closed.

3.19.2.10 Panel lights. Shielded panel lighting shall be provided for the electrical group.

3.19.2.11 Panel light switch. A panel light switch shall be provided to control the set panel lights.

3.19.2.12 Battle short switch. A switch shall be provided and connected to prevent shutdown of the engine and/or opening of the circuit breaker under the action of any safety or protective device (except overspeed and short-circuit). It shall be provided with a hinged red cover, which can be quickly raised to provide access to the switch and which returns the switch to the "OFF" position when lowered. An interlock circuit shall be provided in the set such that the set cannot be cranked; unless this switch is in the "OFF" position.

3.19.2.13 Battle short indicator. A press-to-test indicator light with red lens shall be provided and connected to energize when the battle short switch is in the "ON" position.

3.19.2.14 Frequency adjust device. A device with adjusting knob shall be provided to permit adjustment of set frequency as required herein. Clockwise rotation of the knob shall cause set frequency to increase. The device shall be labeled to indicate clockwise rotation to increase frequency. This requirement does not apply to DC sets.

3.19.2.15 Voltage adjust device. A device with adjusting knob shall be provided to permit adjustment of set output voltage as requires herein. The control panel shall be marked to show that direction of rotation for increasing voltage is clockwise.

3.19.3 Malfunction group. The malfunction group shall consist of a separate indicator lamp (with yellow lens) which will energize (light) on the action of each protective device (3.37.1 and 3.37.2). The group shall be provided with a test/reset switch which shall permit test and reset of all lamps simultaneously. Means shall be provided such that only the lamp associated with a particular malfunction will energize if the set shuts down (or if the circuit interrupter opens) as a result of that malfunction. MIL-STD-1472 (5.2.2.1.13 through 5.2.2.1.18) shall influence design of the malfunction group. Malfunction indicator lights shall remain energized until reset. In lieu of the separate malfunction indicator lamps another method of presenting the same information and functions may be provided if all other requirements herein are met.

3.20 Protection system. The set shall be equipped with protective devices to accomplish functions as described herein. Unless otherwise specified, the devices shall be arranged in "fail-safe" circuits (6.3.22). Each device shall be capable of performing its function independently without reference to any other protective device. Each device shall cause the appropriate malfunction indicator to energize.

3.20.1 Engine shutdown protective devices. The following protective devices shall act to simultaneously open the set output circuit interrupter and stop the set.

3.20.1.1 Overspeed. This device shall activate at a value recommended by the engine manufacturer to shutdown the set before engine damage. It shall not be actuated from the exciter voltage, generator output voltage, battery charger, battery voltage, fuel-metering system, or from any linkage under the control of the governor. It shall be provided with a permanently identified manual reset. An overspeed protective device need not be provided on sets that have an electrical governor with a mechanical governor backup if the set can operate continuously at the speed setting of the mechanical governor.

3.20.1.2 High temperature. This device shall actuate at the temperature recommended by the engine manufacturer to shutdown the set before the engine is damaged.

3.20.1.3 Low oil pressure. This device shall actuate when oil pressure drops to the minimum value recommended by the engine manufacturer to shutdown the set before engine damage.

3.20.1.4 Low fuel level. This device shall operate to shutdown the set when the fuel level falls to a point at which it contains sufficient fuel to operate the set at rated load for a minimum of one minute.

3.20.2 Electrical interruption protective devices. The following devices, associated with electrical output shall be provided. These devices shall operate only to open the set output circuit interrupter, except where otherwise required.

3.20.2.1 Overvoltage. This device shall actuate to shutdown the set in not more than 1-1/4 seconds after the voltage in a 120 volt generator coil winding has risen to and remained at any value greater than 153 +3 volts for not less than 200 milliseconds. For DC sets, the device shall operate to shutdown the set in the event that the output voltage exceeds 35.5 volts and remains outside this limit for 0.75 seconds.

3.20.2.1 Undervoltage. This device shall be connected across the same generator coil winding as the overvoltage protective device. When the voltage drops below 48 volts this device shall open the output contactor instantaneously. It shall not operate instantaneously at voltage above 65 volts. In addition, the device shall operate in 6 + 2 seconds after the voltage has fallen to and remained at not more than 99 + 4 volts. For DC sets, this device shall operate to open the output contactor when the output voltage falls below 20 volts and remains below this value for 0.75 seconds.

3.20.2.3 Short-circuit. This device shall open the output contactor within 50 milliseconds in the event set output current in any phase exceeds 425 + 25 percent for both series and parallel connection of generator windings.

3.20.2.4 Overload. This device shall open the output contactor on an inverse time principle and shall not trip when current in any phase is less than 110 percent of rated value. It shall trip within 8 +2 minutes for 130 percent of rated current in any phase.

3.21 Skid base. The skid base shall extend beyond any component of the set. The skid base shall be provided with a method to drain spilled liquids from the interior of the set. There shall be at least a two-inch clearance between the lowest projection of the set and the bottom of the skid base. The set shall not move or walk while operating unrestrained on a level concrete surface under all operating specified conditions.

3.21.1 Engine and generator mounting. Mounts shall be resistant to fuels, lubricants, hydraulic fluids, coolants and greases (6.3.20).

3.22 Housing. The set housing shall be removable. It shall exclude wind-driven rain, snow, and sleet from the set interior to meet the requirements herein. The set housing shall be removable to perform

maintenance actions, including overhaul, requiring removal of the engine, generator, and other components. The housing shall have access doors as necessary for maintenance and shall support 200 pounds per square foot (psf) at any point on the top, without permanent deformation. Housing doors shall be self supporting in the open position.

3.22.1 Document compartment. A compartment shall be provided to store technical publications. The compartment shall be a minimum of 10 x 12 x 4 inches. Temperature in the compartment shall not exceed 170°F under all operating conditions.

3.23 Detailed requirements.

3.23.1 Overspeed. The sets shall be capable of operating at 115 percent of rated speed for a period of 5 minutes without damage (6.3.17). Rated speed for Mode II and Mode III sets shall be that required by the contractor of the set to produce rated frequency.

3.23.3 Smoke limits. The set engine shall operate under all conditions specified herein at all set loads with a smoke reading of not more than 4.0 when measured and analyzed as specified (4.7). Overload and transient conditions are excluded.

3.23.4 Maximum power. The minimum acceptable peak power level shall be 110 percent of rated load under all operating conditions specified herein.

3.23.5 Fuel consumption. The rated load fuel consumption shall not exceed 0.09 gallon per kilowatt hour.

3.24 Handling.

3.24.1 Set lifting attachments. The set shall be provided with a lifting attachment located at the top of the set in such a manner that the set will not be damaged (6.3.10 and 6.3.17) and the set will remain within 15 degrees of level when lifted. The attachment shall carry a minimum of eight times the dry weight (6.3.19) of the set. When welded construction is used for the lifting attachment, this weldment shall be reinforced by bolts, each reinforcement capable of carrying 2.5 times the dry weight of the set. The inside diameter of the attachment eyes shall be not less than 2 inches. The lifting attachment shall not restrict accessibility to the engine and generator or the removal of engine parts, or it shall be of bolted construction for disassembly where necessary to meet this requirement. The lifting attachments, when not in use, shall not increase the overall height of the set. The lifting attachments shall be marked "LIFT POINT".

3.24.2 Skid base structural integrity. Each end of the skid base shall withstand a pull of five times the weight of the set without permanent deformation.

3.24.3 Air transportability. Sets shall meet the air transportability requirements of MIL-A-8421 at altitudes up to 50,000 feet when the set is loaded into aircraft with the longitudinal axis of the set parallel to the

longitudinal axis of the aircraft (either way). The generator set shall be equipped with tie downs. The tie downs shall meet the requirements of MIL-A-8421. The set shall be stenciled "Tie-down" in white near each of the tie downs.

3.24.4 Inclined transportation. The sets shall be capable of being transported while in an operable condition, but not operating, when inclined at any angle from horizontal to 25 degrees from horizontal in any direction with no spillage or seepage from the set or any of its components with the fuel tank at any possible level.

3.24.5 Rough handling. The set shall not be damaged (6.3.17 and 6.3.10) by rough handling which would be encountered during normal railroad, truck or trailer, aircraft, and helicopter transportation (6.3.11, 6.3.12, and 6.3.24).

3.24.6 Forklift openings. Openings shall be provided in the skid base to permit insertion of fork lift tines. Each opening shall be not less than 11 x 3 inches in size and the openings shall be located such that the center of gravity of the set falls approximately midway between centers of the fork lift openings. The distance between centers of the openings shall be a multiple of 2 inches, but not less than 24 inches nor more than 60 inches. The openings shall be reinforced and equipped with guides such that the set will not be damaged if it is lifted by a forklift, the tines of which do not extend completely through the base. Each opening shall be marked "FORKLIFT HERE".

3.24.7 Engine/Generator lifting attachments. A single lifting attachment shall be provided for removal of both the engine and generator. Assemblies lifted shall remain within 15 degrees from level. The lifting attachment shall withstand, without damage, a minimum of 2.5 times the weight of the lifted assembly. The inside diameter of the attachment eye shall be not less than 2 inches.

3.25 Storage. The set shall not be damaged (6.3.6 and 6.3.17) by prolonged storage (2-3 years) in temperatures from +160°F to -50°F at any relative humidity possible for temperatures within that range. The set shall not be damaged (6.3.6) by exposure to the humidity test as specified (4.7.10). The sets shall require no maintenance during storage and shall be capable of being ready to operate with no more than four man-hours (in a four-hour period) of maintenance after removal from storage. The set without packaging shall not be damaged (6.3.6 and 6.3.17) by exposure to the humidity test specified (4.7.10). The set without packaging shall not be damaged (6.3.6 and 6.3.17) by storage of up to 4 months in a salt fog environment.

3.26 Safety. The sets shall meet the provisions of MIL-STD-882, MIL-STD-1472 (5.13), and MIL-STD-454 Requirement 1. Exposed parts hazardous to personnel shall be insulated, enclosed, or guarded without impairing the functioning of these parts.

3.26.1 Flexural vibration and critical speeds. The set shall be free from dangerous flexural vibrations (6.3.7) and dangerous torsional critical speeds (6.3.9) between the minimum low idle speed and 115 percent of rated speed.

3.27 Electromagnetic interference. The electromagnetic interference and susceptibility characteristics of the set shall not exceed the UM04 limits for Class C2 equipment of MIL-STD-461. The set shall meet the radio interference limits for engine generators sets as specified in notice 4 of MIL-STD-461.

3.28 Load terminals and receptacles.

3.28.1 Output terminals. For AC sets, four output terminals shall be provided. They shall be conspicuously marked "L_1," "L_2," "L_3," and "L_0,"; terminal "L_0" being neutral. The terminals shall be arranged in line in the sequence "L_1," "L_2," "L_3," and "L_0" when reading from left to right or from top to bottom. For DC sets, two output terminals shall be provided. The terminals shall be conspicuously marked "POS(+)" and "NEG(-)". Terminal studs shall conform to Drawing 69-692-1. Terminals shall be rigidly mounted; studs shall not twist or turn in their mountings when the hexagon nuts are tightened. Wires from the set output terminals to the load shall exit through 3 inch diameter opening below the set control panel. A captive cover shall be provided for this opening when load wires are not in use. An insulated socket wrench with T-handle to tighten hexagon nuts shall be provided with each set. It shall be captive with a synthetic fiber rope and shall be secured inside the set housing when not in use. All terminals shall be protected to prevent accidental contact.

3.28.2 Convenience receptacles. Sets shall be provided with a convenience receptacle located near the control cubicle. If single-phase sensing is used, the receptacles shall be energized from the same winding as the reference voltage of the voltage regulator system. The set convenience receptacle shall be a 125-volt, 15-amp, single-phase, duplex receptacle conforming to MS 16658 and identified with an identification plate. It shall be equipped with spring-loaded (in the closed position) weatherproof covers. The receptacle shall be protected by a 15-amp ground fault circuit interrupter (GFCI) located adjacent to the receptacle. No convenience receptacle is required for DC sets.

3.29 DC control power. A circuit breaker shall be connected in the DC supply ahead of the master switch to protect all control circuits energized from the battery except the battery charger which has a separate protective device or is inherently self protected. The DC circuit breaker shall be mounted on the control panel and shall be the type which shows electrical condition (tripped or closed) by mechanical position. The circuit breaker shall also serve as a shutdown switch for the set. The breaker shall be labeled with the information that identifies it as the DC control circuit breaker and instructions on how to reset the breaker when it trips. All DC control devices shall be suitable for operation on voltages of 20 to 32 V. DC voltage transients resulting from operation of the AC circuit interrupter or any other set mounted device shall not exceed 150 volts measured across any DC component. When the set is not operating no current drain shall be

imposed on the batteries, except the following:

a. Panel lights, when associated switch is in "ON" position.

b. Malfunction indicator lamps which require manual reset.

c. Starting aids, when associated control switch is in "ON" position.

d. Fuel level indicator, when set is not operating, but set master switch is in "ON" position.

3.30 AC circuit interrupter. A dust and waterproof circuit interrupter shall be provided and connected between the voltage reconnection system and the set output terminals. It shall be electrically controlled from the set 24 volt DC system, by means of a switch on the control panel. It shall be a three-pole, three-phase device constructed such that the three sets of main contacts close and open simultaneously through action of a common mechanism. The main contacts shall all close within 50 milliseconds and shall all open within 35 milliseconds when operating on the DC control voltage range specified (3.29). It shall not be possible for any of these main contacts to remain closed while others are open. Auxiliary contacts shall be included and used when necessary. The circuit interrupter shall be connected so that it opens automatically when either the circuit interrupter actuator switch or the master switch is placed in the "OFF" position or the DC control circuit breaker is opened. This shall be accomplished independently from any protective device. Interrupting capacity of the main contacts shall be not less than 10 times rated current for the contacts.

3.31 Wiring. All wire shall be secured neatly into harnesses. Wires in all harnesses shall be of the proper length and shall be so run and secured(with insulated clamps) as to protect insulation against contact with sharp corners and edges, pinching, sharp bending and twisting, abrasion because of vibration or contact with moving parts, and exposure to engine fuel oil, lubricating oil, and parts at high temperatures. Conductors shall not be clamped to, or supported by, fuel or oil lines. Where a cable or wire is run between parts which move relative to each other (as a result of vibration, for purposes of adjustment or inspection, or as a matter of normal operation), sufficient slack shall be left in the harness to allow movement to take place repeatedly without bending or twisting to the point of damaging the wire in any manner. Wires shall not be spliced at any point throughout the length of their runs. A means shall be provided to prevent liquids from coming in contact with any electrical connection for all operating conditions specified herein. All wiring harnesses shall terminate in connectors or terminal lugs at each end or branch. Spade terminals shall not be used. Not more than two terminal lugs shall be attached with any one screw on screw type terminal boards and not more than two terminal lugs shall be attached to any one stud on stud type terminal boards. Terminals on electrical components shall not have more than one wire attached.

3.32 Grounding. All AC electrical components of the set shall be isolated from ground. The neutral output terminal (L_0) shall be connected

to the ground stud by an insulated conductor size AWG 6 or larger using fastening methods other than the split stud features of the applicable stud or terminals. The connecting wire shall readily disconnect from the neutral terminal (L_0). The loose end shall be retained when not in use. Neutral connection of "Wye" connected current transformer secondaries may be connected to circuits leading to the output terminal L_0. Direct current components utilizing chassis or case grounding shall not be used. When specified (6.2), a three-section ground rod conforming to type III, class B of W-R-550 shall be provided for each set. Provisions shall be made for storing the rod in the sets. The rod shall be stored in a manner to preclude set damage from vibration, shock, and impact encountered in transportation and handling. On DC sets, the negative output terminal shall be connected to the ground stud by an insulated conductor size AWG 6 or larger using fastening methods other than the split stud features of the applicable stud or terminals.

3.32.1 Ground stud. A ground stud conforming to Drawing No. 69-692-XXX shall be provided. The stud shall be mounted in the skid base (3.27) in such a manner that it does not project beyond the base structure and is easily accessible.

3.33 Voltage reconnection system. For AC sets, a voltage reconnection system shall be provided for reconnecting the phase windings of the generator to give the specified output voltages. In addition, reconnection of any other circuits required to convert the set voltage/phase output shall be accomplished at the same time and by the device which serves to reconnect the generator stator windings. Conversion of the set operation shall be possible by means of a standard socket wrench in less than 15 minutes. All studs, if used, in the reconnection system shall have square or hexagon-shaped shanks imbedded in an insulating material such that they cannot turn when nuts are tightened or loosened.

3.34 Human factors engineering. The set shall be designed in accordance with accepted criteria of design for Human Factors Engineering as described in MIL-STD-1472C. The set shall be operable and maintainable during day and night by 5th percentile female through 95th percentile male soldiers while wearing specified clothing (3.6 and 3.11.1). Particular design attention shall be given, but not limited to, MIL-STD-1472C: 4 (General Requirements), 5.1 (Control/Display Integration), 5.2 (Visual Display), 5.3 (Audio Display), 5.4 (Controls), 5.5 (Labeling), 5.6 (Anthropometry), 5.9 (Design for Maintainability,), 5.13 (Hazards and Safety).

3.34.1 Servicing, operation and maintenance. The design and construction of the set shall permit routine service and maintenance under military field conditions. Parts which require adjustment or servicing shall be capable of being adjusted or serviced by personnel wearing MOPP IV NBC protective clothing. The set shall be capable of being started and operated by one operator under all conditions. Starting or stopping the set shall not require manipulation of more than one control or switch other than starting aids. Hardware which requires torquing shall be installed so that the nut, bolt, or screw head is accessible for torque wrench application. In assemblies where both a bolt and nut are used, the nut shall be accessible

for torque wrench application. Servicing, operation, and maintenance requirements shall be met by all sets.

3.35 Physical configuration.

3.35.1 Size. The overall dimensions of an operating set shall not exceed 30.0 cubic feet.

3.35.2 Weight. The set dry weight (6.3.25) shall not exceed 650 pounds.

3.36 Treatment and painting. External treatment and painting shall be in accordance with MIL-T-704, type F or G. The following items shall not be painted: Terminal wiring connections, governor linkage, instruction diagrams, plates, rectifiers, relays, circuit breakers, switches, and all other parts whose operation or function would be adversely affected by paint.

3.37 Workmanship. Workmanship shall be in accordance with Requirement 9 of MIL-STD-454. In addition, workmanship shall be of a quality to assure delivery of sets which are free from defects resulting from defective material and incorrect manufacturing or assembly practices.

3.37.1 Castings and forgings. All parts, components, and assemblies of the sets which include castings and forging shall be clean of harmful extraneous material such as sand, dirt, pits, sprue, scale, and flux. Rework shall be limited to procedures which do not reduce strength or affect function.

3.37.2 Metal fabrication. Metal used in fabrication shall be free from kinks and sharp bends. The straightening of material shall be done by methods that will not cause injury to the material. Corners shall be square and true. Flame cutting, using tips suitable for the thickness of the steel, may be employed instead of shearing and sawing. All bends shall be made with controlled means to ensure uniformity of size and shape. Precaution shall be taken to avoid overheating. Heated steel shall be allowed to cool slowly. External surfaces shall be free of burrs, sharp edges and corners, except when sharp edges or corners are required or where they are not detrimental to safety.

3.37.3 Welding. Welding shall be performed in accordance with accepted industry or military standard procedures and practices.

3.37.4 Bolted connections. Bolt holes shall be accurately formed and shall have the burrs removed. Washers or lockwashers shall be provided where necessary. Matching thread areas securing bolts shall be of sufficient strength to withstand the tensile strength of the bolt. All fasteners shall be correctly torqued and shall have full thread engagement.

3.38 Identification, marking, and information. The sets shall be permanently identified and marked and have information and instruction plates as specified herein.

3.38.1 Parts identification. Parts shall be marked in accordance with MIL-STD-130.

3.38.2 Identification plates and decals.

3.38.2.1 Set identification plate. A set identification plate containing the information in Drawing No. 73-0506 shall be mounted in a conspicuous place on the generator set.

3.38.2.2 Generator identification plate. A generator identification plate containing the information in Drawing No. 72-2459 shall be mounted on the generator frame.

3.38.3 Information and instruction plates and markings.

3.38.3.1 Operating instructions. A plate or plates containing operating instructions shall be mounted in a conspicuous location visible from the operators position. The operating instructions shall be complete and brief; shall describe procedures for starting, operating, and stopping at ambient temperatures from 120°F to -50°F; shall state types and quantities of oil, grease, coolant, and fuel to be used over the operating temperature range; shall state information on grounding the set frame with a warning that this should be done to avoid shock hazard; and shall state the polarity of the battery terminal connected to ground.

3.38.3.2 Schematic and wiring diagrams. A plate, or plates containing a schematic diagram and a connection (wiring) diagram shall be mounted in an easily visible location inside of the set. The schematic diagram shall show the complete operational and functional sequence of the circuit for analysis and maintenance of the set. The connection diagram shall show the physical location of all wiring interconnections in the same relationship as when they are installed. Identification marking of instruments, control devices, and connections shall be shown in both diagrams and shall coincide with markings on all items being identified. Electrical symbols shall be in accordance with ANSI Y 32.2. When additional electrical symbols are used for items not in ANSI Y 32.2, the meaning of the symbol shall be defined by a note on the diagram.

3.38.3.3 Grounding stud plate. A plate at the grounding stud shall be marked "GROUND LUG."

3.38.3.4 Fuel system diagram. A plate, mounted in a conspicuous location within the housing, shall show the entire fuel system including the arrangement and notation of the valves and directions for operation from the integral tank and from an external fuel supply.

3.38.3.5 Fuel selector valve instructions. A plate shall be mounted in the vicinity of the fuel-selector valve and shall be marked "OFF", "GEN SET

TANK", and "AUXILIARY" to show valve position for shutting off fuel flow, for passing fuel from the set fuel tank, and for passing fuel from an auxiliary fuel source, respectively.

3.38.3.6 Connection changeover instructions. A plate which illustrates the physical configuration for achieving each of the generator operating connections shall be mounted on or in the vicinity of the reconnection panel. In lieu of a separate plate, the instructions may be printed directly on the reconnection panel.

3.38.3.7 Caution plate for voltage connections. A plate shall be mounted on the housing in the vicinity of the load output terminals stating: "TO AVOID DAMAGE TO THE LOAD: Prior to connecting to this machine, check voltage, frequency, and phase requirements of the using equipment."

3.38.3.8 Convenience receptacle plate. A plate at the convenience receptacle shall be marked "120-volts ac." The plate shall also be marked "60 Hz" or "400 Hz" as appropriate and shall be marked "single phase".

3.38.3.9 Lifting and tiedown attachments diagram. A diagram showing the lifting and tiedown attachments with the lifting capacity of each attachment. A silhouette of the equipment showing the center of gravity shall be provided. The plate shall also show how to mount the sets for railroad transportation.

3.38.3.10 Battery connection plate. The plate shall have a schematic diagram showing the battery cable connections and instructions for removing and installing the batteries. The plate shall be mounted such that it is readable when servicing the batteries.

3.38.3.11 Slave receptacle plate. This receptacle shall have a plate marked "SLAVE RECEPTACLE 24 V DC".

3.38.3.12 Set rating plate. A plate or plates shall be mounted on the control panel end of the set. They shall contain the following information:

a. Kilowatt capacity of the set at different environments with different fuels.

b. Hertz rating of the set (60 Hz, 400 Hz, or DC).

c. Rated voltage and phases available at each connection of the set.

d. Voltage adjustment ranges available at each connection of the set.

e. Power factor.

f. Type, mode, and size of the set.

3.38.3.13 Electrical parts, components, controls, and instruments. All electrical parts, components, controls, and instruments shall be identified by a symbol and a number. The numbers shall be the same as used on the schematic diagram. This identification shall be permanently marked in accordance with MIL-STD-130 in a visible location adjacent to the item on the mounting surface. Each terminal board lug shall be numbered and the number permanently marked adjacent to the lug. All plugs and receptacles shall be identified by symbol and number (P specify, J specify) in accordance with the schematic diagram. Polarity of electrical components which are polarity sensitive shall be permanently marked in visible location on the mounting surface.

3.38.3.14 Fluid lines. Unless otherwise approved by the contracting officer,each fluid line shall be identified in accordance with MIL-STD-1472 (5.13.3).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection/test. Unless otherwise specified, the contractor is responsible for the performance of all inspection/test (6.3.16) requirements as specified herein. Unless disapproved by the Government or otherwise specified, herein or in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection/test requirements specified herein. The Government reserves the right to perform or repeat any of the inspections/tests set forth in this Purchase Description where such inspections/tests are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Disassembly inspection/test. Failure of any inspection/test by the preproduction model generator, generator with excitation system, or generator sets shall be cause for disassembly, in the presence of a Government representative, to the extent necessary to determine the cause of the failure. Each disassembled part shall be examined in detail for compliance with this Purchase Description. Parts not complying with requirements shall be rejected and shall be cause for rejection of the preproduction model set. Reassembly with acceptable components or parts and reinspection/retest shall be the responsibility of the contractor.

4.1.2 Inspection/test failure. Should the Government elect to perform or repeat any inspection/test in this Purchase Description, failure of a set to meet any requirement specified herein shall be cause for refusal by the Government to accept production sets until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiencies. Correction of such deficiencies shall be accomplished by the contractor at no cost to the Government on sets previously produced under the contract. Any deficiencies found as the result of such elective inspection/test will be considered prima facie evidence that all sets accepted prior to the completion of such inspection/tests are similarly deficient unless evidence to the contrary is furnished by the contractor and such evidence is acceptable to the contracting officer. The provisions of this paragraph apply, notwithstanding any prior acceptance of preproduction model sets, preproduction model test reports, or initial production sets.

4.1.3 Component and material inspection/test. The contractor is responsible for ensuring that components and materials used are manufactured, examined, and inspected/tested in accordance with referenced specifications, standards, and drawings as applicable.

4.2 Classification of inspection/test. Inspection/test shall be classified as follows:

a. Preproduction model inspection/test (4.3).

b. Initial production inspection/test (4.4).

c. Quality conformance inspection/test (4.5).

d. Inspection/test comparison (4.8).
e. Inspection/test of packaging (4.9).

4.3 Preproduction model inspection/test. The preproduction models shall be examined and tested as specified herein to determine compliance with the requirements of this Purchase Description. Noncompliance shall be cause for performing the disassembly inspection/test specified (4.1.1). The inspection/test records of the set shall describe:

a. Malfunction evidence of damage, failure, or adjustment (other than adjustments permitted in this Purchase Description and the applicable test methods) which occurs during examination and tests.

b. The cause of the malfunction, damage, or failure, and reason for adjustment.

c. The corrective action taken or required.

4.3.1 Examination. All preproduction models shall be examined to determine compliance with the requirements of this Purchase Description. Noncompliance with any requirement of this Purchase Description shall be cause for rejection of the equipment. This examination shall include an inspection by a Government human factors engineer who will use TOP 1-2-610 to guide his evaluation to assure that the set design complies with design criteria specified in MIL-STD-1472.

4.3.1.1 Examination of components and subassemblies. Examination of components and subassemblies shall be made prior to assembly of the generator or set. Evidence that any components or subassemblies do not comply with the requirements of this Purchase Description shall be cause for rejection of that component or subassembly.

4.3.1.2 Examination of generator, excitation system, and sets. Examination of the model sets shall be made without disassembly. Evidence that the generator, excitation system, or sets do not comply with the requirements of this Purchase Description shall be cause for rejection of the generator, excitation system, or sets.

4.3.2 Tests. All models shall be tested to determine compliance with the requirements of this Purchase Description. Performance or test results which show that preproduction models do not meet the requirements of the Purchase Description shall be cause for rejection of the equipment.

4.3.2.1 Generator. The generators shall be subject to GENERATOR ONLY tests in Table II after successful completion of examination of components and subassemblies (4.3.1.2).

4.3.2.2 Generator sets. The generator sets shall be subject to all GENERATOR SET tests in Table II after successful completion of all testing (4.3.2.1) and the successful completion of examination of generators, excitation systems, and sets (4.3.1.2).

TABLE I

TEST SCHEDULE

TEST NUMBER	TEST	METHOD	REQUIREMENT
	GENERATOR ONLY		
1.	Winding resistance	401.1	3.34.1
2.	High potential	302.1	3.34.4
3.	Insulation resistance	301.1	3.34.1
4.	Overspend	505.3	3.34.5
5.	Open circuit satiation curve	410.1	3.34.8
6.	Synchronous impedance curve (Short circuit saturation curve)	411.1	3.34.8
7.	Zero power factor saturation curve	412.1	3.34.8
8.	Rated load current saturation curve	413.1	3.34.8
9.	Direct-axis transient reactance	425.1	3.34.8
10.	Negative sequence reactance and impedance	422.1	3.34.7
11.	Short-circuit (Mechanical strength)	625.1	3.34.3
12.	Generator power input	415.1	3.34.5.3
	GENERATOR SET		
13.	Railroad impact	740.5	3.13.5
14.	Humidity	711.1	3.14
15.	Start and stop	503.1	3.8
16.	Frequency and voltage regulation, stability, and transient response (Short term)	608.1a	3.7
17.	Frequency and voltage stability (Long term)	608.2	3.7
18.	Overspeed	505.1	3.12.1
19.	Overspeed protective device	505.2	3.37.1.1
20.	Phase balance	508.1	3.7
21.	Circuit interrupter (Short-circuit)	512.2	3.37.2.3
22.	Circuit interrupter (Overload current)	512.2	3.37.2.3
23.	Circuit interrupter	512.3	3.37.1.5 3.37.2.1
24.	Reverse battery polarity	516.5	3.20.7.3
25.	Low oil pressure protective device	515.1	3.37.1.3
26.	Overtemperature protective device	515.2	3.37.1.2
27.	Low fuel protective device	515.5	3.37.1.4
28.	Regulator range	511.1	3.7
29.	Phase sequence	507.1	3.34.5
30.	Frequency adjustment range	511.2	3.7

TABLE I

TEST SCHEDULE (CONTINUED)

TEST NUMBER	TEST	METHOD	REQUIREMENT
31.	Voltage unbalance with unbalanced load	620.2	3.7
32.	Lifting and towing	740.4	3.13.1 3.13.2
33.	Voltage waveform	601.1 601.4	3.7
34.	Voltage dip and rise for rated load	619.2	3.7
35.	Voltage dip for low power factor load	619.1	3.67
36.	High temperature at 120°F with solar radiation	710.1	3.34.2 3.8
37.	Maximum power	640.1	3.12.4
38.	DC control	655.1	3.21 3.20.7.4
39.	Rain	711.3	3.8
40.	Inclined operation	660.1	3.8
41.	Fuel consumption	670.1	3.12.5
42.	Starting and operating (Moderate cold battery start)	701.3	3.8
43.	Motor starting	4....	3.8
44.	Audio noise	4....	3.4
45.	Road	4....	3.13.5
46.	Drop (Ends)	740.3 4....	3.13.5
47.	Air transportability	4....	3.13.5
48.	Electromagnetic interference	4....	3.16
49.	Torsiographing	504.2	3.12.2
50.	Altitude operation	720.1	3.8 3.12.3
51.	Endurance	4....	3.3 3.8 3.17
52.	Salt fog	4....	3.8

NOTES:

1. For AC sets, test shall be conducted with the 120/208 volt connection unless otherwise indicated.

2. View waveform with an oscilloscope having a bandwidth of DC - 1.5 MHz and a usable viewing screen of 8 x 10 cm. The oscilloscope gain shall be adjusted such that one cycle of voltage covers approximately the entire viewing screen. For sample tests, only method 601.4 need be used for the voltage test.

3. All tests listed in the table above shall be conducted on each model set.

4.5 Quality conformance inspection/test.

4.5.1 Examination. Each set shall be examined, without disassembly for conformance to the Purchase Description and drawings. Each set which does not meet a requirement shall be considered to be defective.

4.5.2 Tests. Each set shall be subjected to the tests in Table II. For generator only tests, the tests shall be conducted prior to assembly into the set. Failure of any test shall be cause for rejection.

4.6 Test Procedures.

4.6.1 Instrumentation. Test instruments shall be of the laboratory type that have been calibrated, connected, and operated as specified in MIL-HDBK-705. When the test methods call for the use of voltage and frequency recording type meters, the Texas Instrument Company, Model PDRHXFHXVA-A16-XT or the Gould Part Number 2108-2202-005542 shall be used. Exhaust smoke testing shall be in accordance with the method specified in MIL-STD-1400. Exhaust smoke conditions shall be measured in all altitude testing.

4.6.2 Aural signature test. Instrumentation and procedures for the audio noise test shall conform to MIL-STD-1474. In addition, measure audio noise sound pressure level at no load and rated load using microphone(s) located 1.2 meters above the ground. Also measure audio noise sound pressure levels 1 (one) meter from the control panel at no load and rated load.

4.6.3 Thermal signature test. The surface temperature of the set shall not differ by more than 4°C from ambient when viewed from any angle in the upper hemisphere bounded by the plane of the ground surface under all possible operating conditions specified herein.

4.6.4 Railroad impact test. The railroad impact test shall be performed in accordance with method 740.5 of MIL-STD-705 with the following changes:

a. Paragraphs 740.5.3(a), (c), (e) and 740.5.4 (b), delete "generator" and substitute "generator sets".

b. Paragraphs 740.5.3(b), and (f), delete "Method 614.1, Voltage and Frequency Regulation Test" and substitute "Method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test, on each set, at rated load only."

The generator sets shall be mounted with their longitudinal axis parallel to the length of the flat car. The sets shall not be packaged for the railroad impact tests. Each set shall be subjected to two impacts at 6 miles per hour ($\mp$0.5 mph) for a total of two impacts. One of the sets shall be positioned 180 degrees with respect to the position in which the other(s) are tested. Anchorage of the set to the flatcar shall be as follows: Insert steel channels through the forklift tine openings and securely bolt the channels to the flooring. Blocking timbers, front and rear, shall be used as necessary. Impact speed shall be measured within 60 inches of impact and the speed measurement interval shall not exceed 60 inches in

length. Accuracy of the speed measurement shall be plus or minus five percent. Each set fuel tank shall be drained prior to impact of the sets. Used batteries filled with water may be installed for impact test. All other liquids shall be at normal operating levels.

4.6.5 Drop test. The drop test shall be performed in accordance with method 740.3 of MIL-STD-705 with the following changes:

a. Paragraphs 740.3(a), and (g), delete "Method 614.1, Voltage and Frequency Regulation Test" and substitute, "Method 608.1, Frequency and Voltage Regulation, Stability, and Transient Response Test, on each set, at rated load only."

4.6.6 Electromagnetic interference test. The electromagnetic interference test shall be performed in accordance with MIL-STD-462 and Appendix A.

4.6.7 Air transportability test. The set shall be tested in accordance with MIL-A-8421.

4.6.8 Motor starting test. The motor starting test shall be performed by use of a motor rated NEMA Code F, in accordance with MG-1. The motor shall be loaded with a flywheel or equivalent having an inertia equal to that of the motor rotor. Satisfactory starting is defined as acceleration of the motor to rated speed without tripping any generator set protective devices.

4.6.9 Reliability/endurance/maintainability (REM) test. The REM test shall be conducted on two sets of each mode. The endurance data will be analyzed in accordance with the requirements of 3.4.1. The maintainability data will be analyzed in accordance with the requirements of 3.5, 3.5.1, and 3.5.2. The reliability data will be analyzed in accordance with the requirements of 3.4 and the test plan below. The REM test shall be performed in accordance with method 695.1 of MIL-STD-705. Accept/reject time is total hours of "equipment on" time accumulated on sets of each size and mode during the REM test. Turbine fuel (JP-4) in accordance with 3.12.1 shall be used for 300 hours of operation on each set per 3,000 hours of operation. Fuel containing up to 15 milligrams of AC fine test dust per liter of fuel may be used for all REM testing.

4.6.10 Humidity test. The humidity test shall consist of five consecutive 48-hour cycles as specified in MIL-STD-705, method 711.1.

4.6.11 Road test. Mount the set on a compatibile MIL-SPEC trailer and test to conditions specified (6.3.12). Set shall be in operating condition with the fuel tank one-half full and all other fluids at normal operating levels.

4.6.12 Salt fog test. The salt fog test shall be performed in accordance with method 509.2 of MIL-STD-810. One set of each size shall be subject to alternating 24-hour periods of salt fog exposure and standard ambient(drying) conditions for a minimum of four 24-hour periods. Salt concentration shall be a 5% (± 1%) solution. The sets shall be tested in

their normal operating mode. Any corrosion shall be analyzed for both its immediate and potential long term effects on the proper functioning of the set.

4.7 Inspection/test comparison. The Government may select sets at any time during the contract production period and subject these sets to any examination and test specified herein, necessary to determine that the selected sets meet all requirements of this Purchase Description. The inspection/test will be performed by the Government at a site selected by the Government. Sets will be selected at random from those which have been accepted by the Government and will not include the previously inspected/tested initial production sets.

4.7.1 Inspection failure. Failure of an inspection/test comparison set to meet any requirement specified herein during and as a result of the examination and tests specified in 4.8 shall be cause for refusal by the Government to continue acceptance of production sets until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiencies. Correction of such deficiencies shall be accomplished by the contractor at no cost to the Government on sets previously accepted and produced under the contract. Any deficiencies found as a result of the inspection comparison will be considered prima facie evidence that all sets accepted prior to completion of the inspection comparison are similarly deficient unless evidence to the contrary is furnished by the contractor and such evidence is acceptable to the contracting officer.

4.8 Inspection/test of packaging. Inspection/test of level A or B packaging and preservation shall be in accordance with the quality assurance provisions of MIL-G-28554. Commercial packaging and preservation shall be inspected/tested for compliance with ASTM D 3951.

5. PACKAGING

5.1 Preservation, packing, and marking. Packaging and preservation requirements shall be level A, level B, or commercial as specified (6.2). However, preservative in accordance with MIL-C-16173 shall not be used in liquid cooling systems. Level A and B preservation, packing, and marking shall be in accordance with MIL-G-28554. Commercial preservation, packing, and marking shall be in accordance with ASTM D 951. The crankcase on all sets shall be filled to operating level with preservative lubricating oil conforming to MIL-L-21260, type I, grade 30. Generator sets preserved at level C shall have the engine fuel systems, combustion chambers, and valves preserved in accordance with MIL-E-10062, type II, level A, method I. All sets shall be shipped connected for 120/208 Volts.

5.1.1 Replacement of preservative lubrication oil. The preservative lubrication oil shall be drained and replaced when engines have completed 100 hours of operation. A tag shall be prepared for each crankcase indicating: "This crankcase is filled to the operating level with preservative lubricating oil good for 100 hours - Check Oil Level - If low, elevate the operating level with the operating oil (MIL-L-2104, Applicable grade)". The tag shall be attached to the crankcase fill tube.

5.1.2 Preservation of hydraulic sump. Hydraulic sumps (if used) shall be filled to the operating level with hydraulic oil conforming to MIL-H-5606.

5.2 Connection tag. A connection tag shall be attached to one of the load terminals, stating: "This set is connected for 120/208 Volts, 60 or 400 Hz, or 28 Volts DC."

6. NOTES

6.1 Intended use. The sets are intended to supply power for multipurpose use in military applications.

6.2 Ordering data. Procurement documents should specify the following:

a. Title and date of this Purchase Description.

b. Size, mode, and quantity of first article model sets to be furnished (3.2).

c. When initial production inspection/test is required, and, when applicable(4.4 and 6.4) size, mode, and quantity of initial production sets to be furnished.

d. When ground rods are to be provided (3.24).

e. When batteries are to be furnished with production sets and whether MS35000 or MS52149 batteries shall be furnished (3.30.7.1).

f. When paralleling cables are to be provided (3.35.1).

g. Size of lots for production sets (4.5.2).

h. How the production paralleling sets are to be retained and maintained during life of the contract and how sets are to be refurbished and delivered at the end of the contract (4.7.3).

i. Degree of preservation and packaging required (5.1).

j. When electric and/or fuel burning winterization kits are to be furnished with sets (3.10).

6.3 Definitions.

6.3.1 Pure tone. A pure tone is defined as the condition when the audio noise sound pressure level in any octave band exceeds those in both of the two adjacent octave bands (both sides) by 5 dB or more.

6.3.2 Rated load. Rated load is the rated kW at the rated power factor, frequency, and voltage for AC sets. It is 28 Volts, 357 amps (10 kW) for DC sets.

6.3.3 Start. A set is considered to have started when it is operating at rated voltage and speed without the further use of starting aids.

6.3.4 Stop. A set is considered to have stopped when all rotating members are at zero rpm, with the exception of a turbocharger if used.

6.3.5 Critical failure. A critical failure is defined as a relevant failure requiring removal for repair of the engine, cylinder head, oil pan, gear cover, or AC generator. Critical failures are used to determine compliance with the requirements (3.8.3).

6.3.6 Temperature and humidity damage. Temperature and humidity damage is defined as conditions causing malfunction of any component or part, corrosion, breakage, deformation, or reduction of insulation resistance below 50,000 ohms.

6.3.7 Dangerous flexural vibration. Dangerous flexural vibration is defined as a vibration which occurs at a speed at which maximum stress in the shaft from flexural vibration exceeds 9,000 psi.

6.3.8 Stable (set) operating conditions. Stable (set) operating conditions are the conditions specified for short-term, steady-state performance.

6.3.9 Dangerous torsional critical speed. Dangerous torsional critical speed is defined as the speed at which maximum vibrating stress in the shaft from torsional vibration exceeds 5,000 psi.

6.3.10 Rough handling damage. Rough handling damage is defined as any condition resulting in malfunctioning of the set, deformation, loosening, breakage, or change of fit of any component or part.

6.3.11 Normal railroad transportation. Normal railroad transportation shall be interpreted to mean impact speeds up to and including 10 miles per hour under test conditions specified in MIL-STD-705, method 740.5.

6.3.12 Normal truck or trailer transportation. Normal truck or trailer transportation is defined as the conditions encountered during four cycles of a road test, each cycle consisting of the following, with the set mounted on the trailer(s) specified on the applicable specification sheet.

ROAD CONDITION	DISTANCE (MILES)	SPEED (MPH)
Paved Highway	250	up to 50
Level Cross Country	250	up to 20
Hilly Cross Country	125	up to 20
Belgian Block	15	up to 20

6.3.13 Normal aircraft and helicopter transportation. Normal aircraft and helicopter transportation shall be interpreted to mean a 12-inch end drop under test conditions specified in MIL-STD-705, method 740.3.

6.3.14 Failure. A failure is defined as the inability of an item to perform within specified limits. The contracting officer will identify all failures and will classify them into the following categories:

6.3.14.1 Relevant failure. Any failure of an item which prevents the set from meeting the power output requirements, aural signature requirements, or thermal signature requirements specified herein. Relevant failures shall be used to compute reliability.

6.3.14.2 Failure detection. A failure which would prevent the set from meeting any power output requirement specified herein is relevant notwithstanding the fact that it is detected during a shut-down for service and did not cause the set to perform out of limits during the previous testing (e.g., a shutter failure on a 40°F day might not cause malfunction, but would preclude operation at extreme temperatures and is therefore relevant, even if detected during shutdown for service).

6.3.14.3 Nonrelevant failure. Any failure of an item which is not used to compute reliability. Examples of nonrelevant failures are as follows:

a. Secondary failures caused by failures in the powered equipment or other occurrences in the set environment when integral set protection is not provided against occurrence of such equipment failure, e.g., explosion or fire.

b. Failures due to characteristics of the load, e.g., waveform distortion caused by saturated inductors.

c. Failures due to design deficiencies when subsequent testing demonstrates that the design deficiency has been corrected, e.g., belts fail at an average life of 100 hours and a new belt demonstrates a mean life greater than required life the 100-hour failures are considered nonrelevant failures

d. Secondary failures caused by primary failures due to a design deficiency, when subsequent testing demonstrates that the design deficiency has been corrected, e.g., radiator damage due to the 100-hour belt failure in "c" above.

e. Failures resulting from operating items beyond requirements, e.g., if belts are run to failure to determine mean life, failures after the required belt life are not relevant failures.

f. A failure of an item which does not prevent the set from meeting the power output requirements specified herein, e.g., a panel light burns out.

g. Failures due to operator error where proper procedures are documented in Technical Manuals, instruction plates mounted on the set, or both; e.g., use of improper lubricant.

6.3.15 Accuracy/error. Accuracy is a ratio which defines the limit of error expressed as a percentage of full-scale value. Error is the difference between the indication and the true value of the quantity measured. It is the quantity which, when algebraically subtracted from the indication, gives the true value. A positive error denotes that the indication of the meter is greater than the true value.

6.3.16 Inspection/test. Inspection/test is the examination and testing of supplies or services including, when appropriate, raw materials, components, and intermediate assemblies to determine conformance with contract requirements.

6.3.17 Damage. Damage is defined as any failure (6.3.14), rough handling damage (6.3.10) or degradation in life. The blowing (opening) of a replaceable fuse is not considered damage, provided it is performing its intended function.

6.3.18 Maintenance ratio. The maintenance ratio is defined as the average maintenance manhours per operating hour for all scheduled and unscheduled set maintenance. Maintenance manhours include any and all manhours expended for scheduled and unscheduled maintenance before, during, and after services, including time expended for inspection, diagnosis, and adjustments of the set and repair of failed components and assemblies.

6.3.19 Dry weight. The weight of the set is a dry weight and does not include the weight of fuel, lubricating oil, electrolyte, coolant, hydraulic oil, and optional equipment.

6.3.20 Fuel, lubricant, and grease resistant. Fuel, lubricant, and grease resistant is defined as being capable of a 1-second immersion in any fuel, lubricant, or grease used in the sets, every 24 hours for a total of 240 hours without degradation to the point where it will no longer serve its intended use, or in the case of engine and generator mounts, to the point where they will not pass the railroad impact test.

6.3.21 Drip proof enclosures/boxes. A drip proof enclosure/box is an enclosure/box so constructed that falling drops of liquid or solid particles striking the enclosure/box at angles from 0 to 15 degrees from the vertical cannot enter the enclosure/box either directly or by striking and running along a horizontal or inwardly inclined surface.

6.3.22 Fail-safe. If electrical, a circuit arrangement such that a malfunction anywhere in the circuit (broken wire, etc.) will shut down the set and/or prevent the set from being started. If mechanical, an arrangement such that the failure of any part will return the device to a condition to limit the damage to the failed part or parts.

6.3.23 Frequency and voltage regulation. Frequency and voltage regulation is defined as the difference between the no load value and the rated load value divided by the rated load value. To express regulation as a percentage, multiply the value found by 100.

6.3.24 Overshoot and undershoot. Refer to MIL-STD-705, Figure 608.1-IV for definition of overshoot and undershoot.

6.3.25 Total operational weight. The total operational weight of the set is a wet weight and includes the weight of the fuel, lubricating oil, electrolyte,coolant, hydraulic oil at full capacities and optional equipment.

APPENDIX A

ELECTROMAGNETIC EMISSION and SUSCEPTIBILITY REQUIREMENTS FOR CONTROL OF ELECTROMAGNETIC INTERFERENCE

10. SCOPE

10.1 Scope. This document clarifies the limits, test methods and general procedures to be used for measurement of EMI on Mobile Electric Power Generating Sources (MEPGS). Clarification as to the use of MIL-STD-462 is included. This document is intended to be used as a clarifying supplement for the use of MIL-STD-462 but does not replace MIL-STD-462.

20. APPLICABLE DOCUMENTS

20.1 Issue of documents.

MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference, dated 4 August 1986.
MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of, dated 31 July 1967 and Notice 3 (EL) thereto, dated 9 February 1971.
MIL-HDBK-705 - Generator Sets, Electrical, Measurements and Instrumentations.

30. GENERAL REQUIREMENTS

30.1 Class C equipment requirement. MIL-STD-461 establishes Class C2 for engine generators and associated components, Uninterruptible Power Sets (UPS), and Mobile Electric Power (MEP) equipment supplying power to or used in critical areas. The UM04 limits for conducted emissions and radiated emissions listed in Part 9 of MIL-STD-461 are applicable to sets rated at 240 kVA or less. The UM04 limits for radiated emissions may be extended to sets with a rating greater than 240 kVA when specified in the procurement document. The UM04 limits for radiated susceptibility are applicable to all generator sets regardless of rating.

30.2 Limits and frequency ranges. Part 9 of MIL-STD-461 establishes the following information:

a. Conducted Emissions, 0.015 to 50 MHz, Power Leads.

b. Radiated Emissions, 14 kHz to 1 GHz, Electric Field.

c. Radiated Susceptibility, 2 MHz to 10 GHz, Electrical Field.

Figures 9-1 and 9-2 of Part 9 establish the criteria for broad band conducted and radiated emissions. The criteria for radiated susceptibility is that the set shall not exhibit any malfunction, degradation of

performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment specification when subjected to the following radiated E-fields in the frequency range of 2 MHz to 10 GHz:

FREQUENCY	E-FIELD RANGE (Volts/meter)
2 to 400 MHz	10
400 MHz to 10 GHz	5

Above 30 MHz the requirement shall be met for both horizontally and vertically polarized waves.

40. QUALITY CONFORMANCE INSPECTION

40.1 Test procedures. Applicable test procedures for determining conformance to UM04 limits are contained in Notice 3 (EL) to MIL-STD-462. Specifically,methods CE04, RE02, and RS03 shall be used for conducted emissions, rated emissions, and radiated susceptibility respectively. These test procedures are clarified by the attached supplementary test methods.

TEST METHOD NO. 1

CONDUCTED EMISSIONS

1. Test method. MIL-STD-462, Notice 3 (EL), method CE04, procedure (A) conducted emissions 50 kHz to 50 MHz, power leads.

2. Frequency limits. 0.015 to 50 MHz.

3. Applicability. Applicable in testing to requirement of Figure 9.1 of part 9 of MIL-STD-461.

4. Apparatus.

a. Delete: The use of Line Impedance Stabilization Networks (LISNs) and 50 OHM resistive terminations is not required.

b. Add: Fifty-foot load cable and resistive/reactive load bank. The rating of the load bank shall be of sufficient capacity to load the MEPGS to rated capacity at both unity and 0.8 power factor.

5. Procedure. With the 50-foot cable connected to MEPGS output and energized, determine the broad band conducted emissions (0.015 - 50 MHz) on each conductor at the end of the cable at no load, rated kW load at 1.0 pf, and rated kW load at 0.8 pf at all voltage and frequency connections.

6. Failure criteria. Conducted emissions exceeding the limit of Figure 9.1 of MIL-STD-461 shall be cause for rejection.

7. Other.

a. The 50-foot cable shall be energized during the no load test.

b. The 10 microfarad feedthrough capacitors used in superseded test methods are not used in this test method.

TEST METHOD NO. 2

RADIATED EMISSIONS

1. Test method. Notice 3 (EL), method RE02, radiated emissions, electrical field.

2. Frequency limits. 14 kHz to 1 GHz.

3. Applicability. Applicable in testing to requirements of Figure 9.2 of Part 9 of MIL-STD-461.

4. Apparatus. Add a 50-foot load cable and a resistive/reactive load bank. The rating of the load bank shall be of sufficient capacity to load the MEPGS to rated capacity at both unity and 0.8 power factor.

5. Procedure.

a. In lieu of continuously welded bond for the counterpoise, bonding straps shall be used.

b. With the 50-foot cable connected to the MEPGS output and energized, determine the radiated emissions (14 kHz - 1 GHz) at no load, rated kW load at 1.0 pf, and rated kW load at 0.8 pf at all voltage and frequency connections.

6. Failure criteria. Radiated emissions exceeding the limit of Figure 9.2 of MIL-STD-461 shall be cause for rejection.

7. Other. The 50-foot cable shall be energized during the no load test.

TEST METHOD NO. 3

RADIATED SUSCEPTIBILITY

1. Test method. Notice 3 (EL), Method RS03, Radiated Susceptibility, 14 kHz to 12.4 GHz, electrical field.

2. Frequency limits. 2 MHz to 10 GHz.

3. Applicability. Applicable to testing MEPGS.

4. Apparatus. Add a 50-foot load cable and a resistive/reactive load bank. The ratings of the load bank shall be of sufficient capacity to load the MEPGS to rated capacity at both unity and 0.8 power factor. The output monitor shall be a recording voltage and frequency meter in accordance with MIL-HDBK-705.

5. Procedure.

a. With the 50-foot cable connected to the MEPGS and energized, subject the set to electric fields to 10 V/m (2-400 MHz) and 5 V/m (400 MHz to 10 GHz) at no load, rated kW load at 1.0 pf, and rated kW load at 0.8 pf at all voltage and frequency connections.

b. The set output voltage shall be monitored throughout the test with the recording voltage and frequency meter operating at six inches per hour until voltage or frequency variations as a function of field strength or frequency are noted. Upon observing such variation, the chart speed shall be increased to six inches per minute and the frequency spectrum in question shall be rescanned for acceptance/rejection analysis.

6. Failure criteria. Failure of the output voltage or frequency to remain within the 30-second short-term stability bandwidth (specified in the procurement document) when subjected to the specified electrical fields shall be cause for rejection.

7. Other. The 50-foot cable shall be energized during the no load test.

APPENDIX B

NUCLEAR ENVIRONMENTS

GENERATOR SETS, TACTICAL, QUIET

60 and 400 HERTZ

The sets shall operate as specified in Section 3 of this Purchase Description after being subjected to the applicable nuclear environments specified herein. Specific area of testing is electromagnetic pulse. Sets shall be subjected to the applicable nuclear environments specified in Nuclear Survivability Criteria for the Commercial Generator Sets and Assemblages during testing.

APPENDIX C

NUCLEAR, BIOLOGICAL and CHEMICAL

CONTAMINATION SURVIVABILITY CRITERIA

GENERATOR SETS, TACTICAL, QUIET

60 and 40 HERTZ

Decontaminability criteria, hardness criterion and compatibility criterion shall be as specified in NBC Contamination Survivability Criteria for Army Material (Revised).